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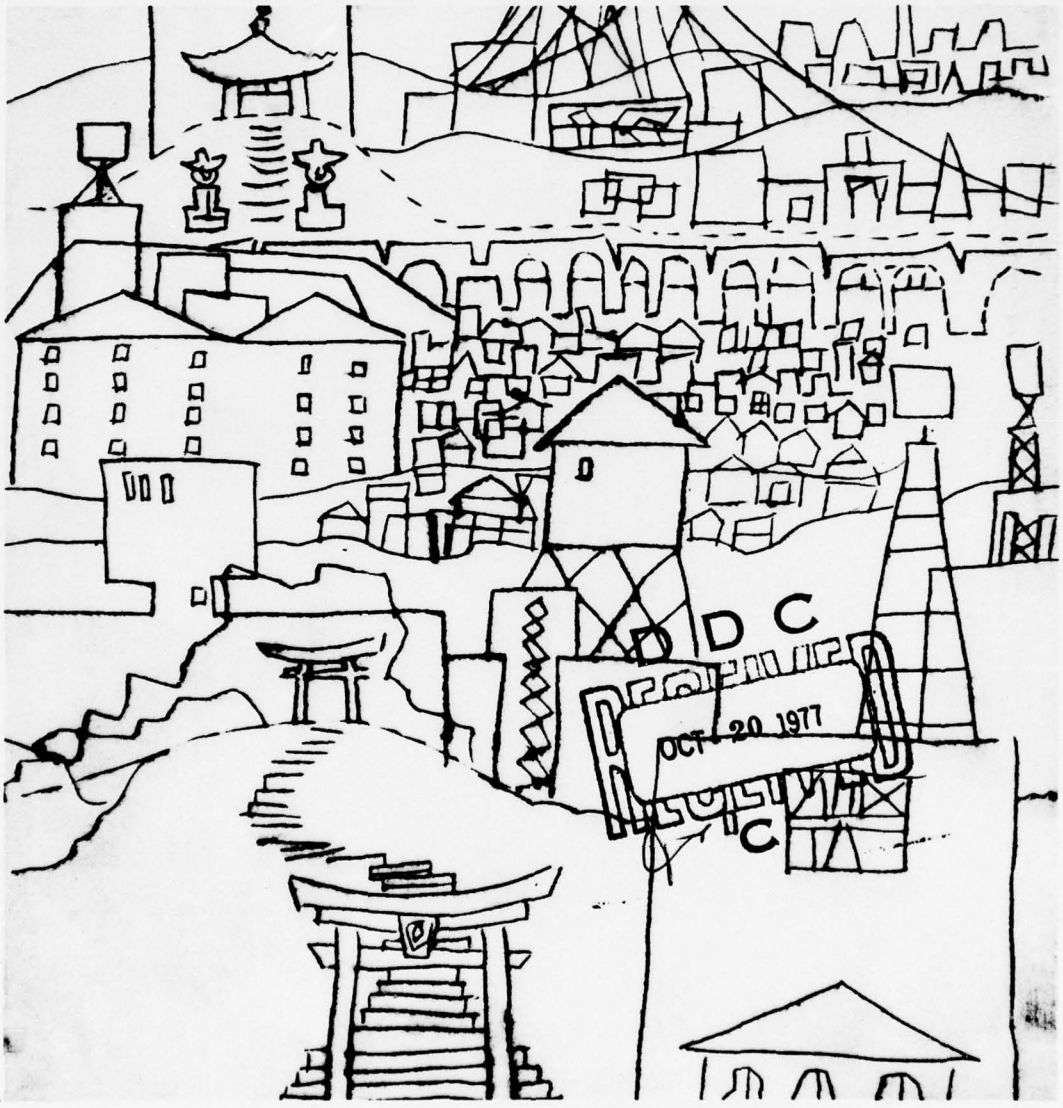
DEPARTMENT OF THE NAVY OFFICE OF NAVAL RESEARCH TOKYO



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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally

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19. KEY WORDS (CONT.)

Steel
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Radiation Chemistry
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Psychological Research

20. ABSTRACT (CONT.)

a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

GUEST CONTRIBUTORS TO THIS ISSUE

David Aminoff is Associate Professor of Biochemistry in Internal Medicine at the University of Michigan Medical School. He is interested in the immunogenetics as well as the biosynthesis and degradation of the ABO blood group substances. The techniques and concepts developed in this area are constantly being extended to the much wider field of glycoconjugates. One compelling application of the technology developed so far to which he is dedicated is the preparation of a Universal Blood Donor Type.

George Sandoz is a metallurgical engineer on the staff of ONR Chicago, who served a brief tour of duty at ONR Tokyo. His special interests are stress corrosion cracking, hydrogen embrittlement, corrosion fatigue, and fracture in steel and titanium alloys. He has also studied the notch ductibility and graphitization kinetics of cast irons and protective coatings for refractory metals.

Arnet L. Powell is Chief Scientist of ONR Boston. He also holds an appointment as Guest of the Institute (M.I.T.) in physical organic chemistry. Research interests include physical chemistry and organic chemistry, with particular emphasis on the kinetics and mechanisms of reactions taking place in solution.

Carl Hewitt is a professor of computer science at the Massachusetts Institute of Technology. A specialist in the procedural representation of knowledge, he is probably best known for his early work on the structure of plans in problem solving. More recently under an ONR contract, his group at M.I.T. has developed a theory of communicating parallel processes that shows promise in aiding the analysis of distributed Naval message-passing systems.

K. O. Bowman is a research staff member of the Mathematics and Statistics Research Department, Computer Sciences Division, Union Carbide Corporation, Nuclear Division at Oak Ridge, Tenn., prime contractor of the Energy Research and Development Administration. Her main interest is research in distribution and estimation theory and their application. She recently spent a three month tour of duty as a visiting scientist at ONR Tokyo.

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THE COVER: A reproduction from a dry point print by Margaret Kennard Johnson, who also did the first cover for ONR Tokyo. It is the artist's impression of the blending of industrial Japan with the traditional–the modern and the ancient.

THE TRAVELLING SYMPOSIUM

David Aminoff

The purpose of this trip was primarily to attend the VIII International Symposium on Carbohydrate Chemistry held in Kyoto, Japan, August 16-20, 1976. In addition, I took the opportunity to meet and discuss with specific scientists problems connected with our current research endeavors, and to visit some of the scientific labs en route.

The American Chemical Society, under the auspices of a local travel agent, organized the group flight. It was by all standards a highly successful and economical arrangement. The travel itinerary included Chicago, Anchorage (meeting points for the Americans and Canadians), Tokyo, Kyoto, Hong Kong, Bangkok, Taipei, and Hawaii.

We have all experienced at one time or another a scientific meeting held in complete isolation. The close proximity of the delegates is initially welcomed for the opportunity it affords to make new acquaintances or to meet old friends and colleagues, but with time, the meeting soon wilts in the monotonous environment. In contrast a meeting held in a large city with its many exciting distractions soon loses its delegates and identity in the enormity of its environment. The Travelling Symposium surely provides the optimal solution. Here we found ourselves, a group of congenial colleagues thrown together for a period of close to three weeks, spiced with an exciting and constantly changing environment during the tours and with every opportunity to learn of each other's work and thereby deepen our respect for each other's achievements. Such a climate is most conducive for mutual understanding and future collaboration.

Our group consisted of 38 Americans and Canadians. The flight must certainly have been the longest day of our lives, since we saw no night in a trip that spanned two days and lost one in the bargain. The overall foreign contingent at the conference comprised 200, and they were matched by some 550 Japanese representatives. There were no candidates from the USSR or Czechoslovakia, although delegates were present from East Germany and Poland. Of the foreign delegates, the American representation, as usual, was the largest and most active.

The previous meeting held in the States was the VIth in August, 1972, and the meeting following that was in Bratislava. The next two meetings are to be held in England and Australia, respectively. As such, these meetings serve as excellent milestones in the documentation of the progress of the science and a reflection of the change in emphasis of the scientists concerned. There was, for instance, at this meeting a much greater interest in biochemical aspects of the field than was evident previously.

The Symposium was held in the International Conference Hall in the old Imperial capital of Japan—a gem set in the beautifully landscaped suburbs of Kyoto resplendent with magnificent temples, shrines and palaces. Add to that the typical Japanese meticulousness to administrative details and spice it with their legendary hospitality and courtesy and you have the prescription for a first-class symposium.

The meeting was organized by the Science Council of Japan which was supported by scientists affiliated with the Agricultural Chemical Society, Chemical Society, Biochemical Society and Pharmaceutical Societies of Japan, accounting for the strong representation of the Japanese delegation. Since the central theme of the Symposium was Carbohydrate Chemistry, it is an impressive reflection of the importance attached to this area of investigation by the Japanese. Despite the higher proportion of Japanese scientists, the language of the Symposium was English. It is a credit to our hosts that the majority of the papers were well presented, although the going

was a bit rough when it came to the questions and discussions that followed the presentation of the general papers.

The sessions consisted of Plenary lectures by invited guests in the mornings and General papers in the afternoons. The General papers were divided into five sessions: I–Organic and Physical Chemistry of Carbohydrates, II–Polysaccharides, III–Complex Carbohydrates, IV–Advances in Analysis of Carbohydrates, and V–Industrial and Medical Aspects of Carbohydrates. These five sessions were run simultaneously in different rooms and naturally it was not possible to attend all the meetings. The selection made here is, therefore, dictated by my personal interests.

There was no discussion in the Plenary Sessions which consisted of an up-to-date review by recognized authorities of the general state of the art in their own specific areas. A wide range of topics was handled, some at great depth. There were three separate presentations on the physicochemical aspects of complex biologically active carbohydrates. In some of these the emphasis was on the methodology developed, e.g., B. Lindberg of Sweden and G. O. Aspinall of Canada, in contrast to that of L. Szabo of France where the emphasis was on the application of the different techniques to the elucidation of the structures responsible for the *Bordetella pertusis* endotoxin. One of the Plenary sessions was given by a well-known Japanese investigator, S. Hakomori, presently residing in the United States at the University of Washington, Seattle. His topic dealt with an area relevant to our field of study on the blood groups, namely the "Status of Blood Group H_3-Carbohydrate Chain in Ontogeny and Oncogeny." Another very biochemically oriented area of special interest to us dealt with "Lectins as Carbohydrate-Binding Proteins." This was by a colleague at The University of Michigan, Ann Arbor, I. J. Goldstein. He presented a review of the specificities of the different lectins and then focused on some of his recent work on the "B" specific lectin of *Bandeiraea simplicifolia* which showed occasional cross reactivity with Type A red cells. It appears that there are five distinct isolectins in these seeds ranging in their reactivity with A and B cells. These isolectins are analogous to the LDH isozymes in that they are oligomeric proteins composed of 4 protomers, 2A and 2B, to give the following five isolectins: AAAA, AAAB, AABB, ABBB, BBBB. One of the Plenary lectures dealt with the "Synthesis of Amino- and Branched Chain Mono- and Oligosaccharides." The closing lecture, by R. L. Whistler from Purdue University, Lafayette, Indiana, "Direction of Carbohydrate Research in the Near Future," gave a one man's view of what is in store for us in the future. Like the science fiction of the last generation, there is an awesome feeling that the topics here discussed may indeed be the future titles of the papers of general sessions at the next meeting.

But what of the sessions of general papers at this Symposium? All the material was presented orally, the group was too small to resort to the now common practice of using Poster presentations. However, in my opinion many of the presentations would have been more comprehensible if the Poster format had been used, because of the language problem.

As mentioned earlier, it is impossible to cover all the presentations. Instead, I would like to offer a few vignettes, flavored perhaps by my interests and research pursuits.

Schwarz, *et al.* (Justus Liebig Univ., Giessen, Federal Republic of Germany) were interested in determining the effect of a number of sugars and sugar derivatives as well as of a new antibiotic, Tuniramycin, as inhibitors of viral glycoprotein biosynthesis. The rationale behind these studies was that many of the viruses carry a glycoprotein coat and interference with the synthesis of these glycoproteins would result in a defective incomplete and therefore possibly a noninfective virus. The sugars tested were D-glucosamine, 2-deoxy-2-fluoro-D-mannose. Partial inhibition was demonstrated and the potential mechanisms for these inhibitions discussed.

J. Lehmann, *et al.* (Freiburg Univ., Germany), studying the properties of certain derivatives of simple sugars, noted that 2, 6 anhydro D-*galacto*hept-1-enitol could be converted to 1-deoxy-D-*galactose*-heptulose by β galactosidase. The facile enzyme-catalyzed addition of water to the double bond of the substrate was compared with the normal cleavage of β-galactosyl residues by the enzyme β-galactosidase. This certainly appears to be an interesting reaction in that it is the first apparent of a ketoside being cleaved by an aldosidase and could be of value in interpreting the mechanism of action of aldosidases.

Yakamoto, *et al.* (Osaka Womens Univ., Japan) described a new method for the determination of the sequence of sugars in an oligosaccharide chain starting from the nonreducing end in a manner analogous to Edman's method for proteins. The method involves the formation of cyclic acetal at C4 and C6 of the nonreducing terminal sugar, its conversion to the 3, 6 anhydro ring and finally by the removal of the 3, 6 anhydro sugar by mild acid hydrolysis. This method would not be applicable to oligosaccharides carrying acid labile sugars.

Mester, *et al.* (Institut de Chimie des Substances Naturelle, Centre National de la Recherche Scientifique, GIF-Suryvette, France) reported on some very interesting observations. Using the well-known Amadori reaction, they applied it to the study of interaction of serotonin with D-glucose. The product formed was fully active biologically in its ability to aggregate platelets but it was not incorporated into the platelets, as is true of the free serotonin. Moreover, the derivative is not oxidized by monoamino oxidase. Using poly-l-lysine, it, too, readily forms Amadori type N-substituted 1-deoxy 1-amino-2-ketose sugar derivatives. This derivative loses its ability to aggregate platelets and to inhibit collagen-induced platelet aggregation. The sialyl derivative of poly-lysin behaved in the same way.

J. John Marshall (Biochemical Research Laboratories, Howard Hughes Medical Institute, Florida) reported on the modification of properties of enzymes to which polysaccharide has been attached covalently. The linkage was brought about by reagents used to prepare immobilized enzymes on insoluble polysaccharide matrixes. The conjugated enzymes were separated from the unreactive enzyme and tested. In general the conjugated enzymes had superior stability and were less readily inhibited by naturally occurring proteinase inhibitors. He recommends the use of such derivatized enzymes for the therapy of metabolic disorders.

The role of carbohydrates in tissue culture studies was exemplified by the following reports: M. A. Chester, *et al.* (Clinical Chemistry, University Hospital, Lund, Sweden) using fibroblasts were able to show differences in mannose metabolism in normal and heterozygote individuals and patients with mannosidosis.

P. J. Kent, *et al.* (Durham Univ., England) demonstrated the incorporation of fluorosugars into glycoproteins and hyaluronic acid by rabbit tracheal explants in culture. The N-fluoroacetyl residues appear to be resistant to and are possible inhibitors of the enzymatic hydroxylation step of the acetyl group in the conversion to glycolyl neuraminic acids. The fluorinated hyaluronic acid derivative was degradable with hyaluronidase and glucuronidase.

E. F. Walborg's group from Anderson Hospital, Texas, reported on their partial purification, from Novikoff ascites hepatoma cells, of a glycoprotein that reacted strongly with concanavalin A. Electrophoretically the product obtained was still heterogeneous, but the procedures developed should be of great value for the isolation of other membrane glycoprotein components.

Sialic acid, because of its general lability and rapid disintegration, was one of the more recent sugars to be discovered in biological materials. But with the development of more gentle techniques, it is apparent that sialic acid and its derivatives are widely distributed in animal kingdom, no doubt playing an important physiological role in the organism. The following are a few of the topics presented involving sialic acid.

R. Schaurer and his group (Ruhr-University, Bochum, GFR in collaboration with Rijks University, Utrecht, The Netherlands) gave evidence for their belief in the existence of a number of new sialic acid derivatives isolated from human serum and saliva; 9-0-acetyl-N-acetylneuraminic acid and 9-0-L-lactyl-N-acetyl-neuraminic acid as well as the more common N-acetyl-neuraminic acid (NAN). The 9-0-acetyl-NAN was also found in human stomach, kidney and liver. An unsaturated sialic acid derivative, 2-deoxy-2, 3-dehydro-N-acetyl neuraminic acid has been found in human serum, saliva and urine, and it was postulated to be an inhibitor of bacterial and viral sialidases, thus serving as a protective mechanism for the host.

J. P. Kamering, *et al.* (University of Utrecht, The Netherlands) used mass spectrometry together with gas-liquid-chromatography to resolve a mixture of the sialic acids. The method was applied to the (a) identification of O-acetyl and O-L-lactyl-sialic acids, (b) identification of the unsaturated sialic acid, described above, and (c) identification of O-acetyl- and O-methyl groups in synthetic sialic acids.

Many an antigenic specificity has been completely masked or mitigated in its reactivity with its antibody by the presence of sialic acid on the molecule. Indeed, sialic acid has thus been accused of enabling some antigens to evade the natural immunosurveillance system of the host.

E. Miller, *et al.* (Univ. of Pennsylvania, Philadelphia) presented her preliminary data on the effects of the removal of the terminal sialic acids from the four major types of tumors studied: melanoma, intestinal, breast and ovarian tumors, using the *Vibrio cholera* sialidase. The enzymatic treatment was followed by examination of the biological material for changés in morphology and histochemical reactivity and for the determination of % of total sialic acid released. No clinical trials were reported upon.

E. Regoecz, *et al.* (Hamilton, Canada) recounted his experiences in the difference in the response of avian as compared to mammalian liver recognition sites for asialoglycoprotein. This report was of particular interest to me since it reinforces our findings reported in the recent American Journal of Hematology, which show that there is a similar difference in behavior of asialo-chicken as compared to mammalian erythrocyte. The evolutionary significance of this has yet to be ascertained, but it emphasizes the important role that the carbohydrate moiety of glycoproteins and cell surfaces play as zip-codes to direct the molecules to their appropriate destination.

R. Brossmer, *et al.* (Heidelberg, F.R.G.) who has been involved with the sialic acid story for many years described some of the more recent progress in sialic acid chemistry. Briefly, they can be classified into (a) the synthesis of the L series of sialic acids as contrasted to the naturally occurring D series, (b) the synthesis of the mono and diacetyl derivatives of NAN and a presentation of their properties, (c) synthesis of a diaminosialic acid derivative, which, it is hoped, will help elucidate the mechanism of action of sialidase on its substrates, and (d) the synthesis of a chromogenic substrate for the assay of sialidase comparable to the p-nitrophenyl- or umbelliferyl-glycosides suitable for the detection and determination of the glycosidases.

The blood group a[illegible]ery well represented at this meeting. Indeed one whole morning was devoted to it and presentation o[illegible]ther papers in the field were scattered throughout the Symposium. The blood group substances are [illegible]ntly complex glycoconjugates to provide ample amount of work for many investigators set upon the resolution of their complex structures, be they glycoproteins in secretion (Derivitskaya, *et al.*, Kobata, *et al.*), glycolipids on red cells (Koscielak, *et al.*) or complex oligosaccharides in bacteria (Iseki, *et al.*).

The techniques used involved (a) partial alkaline hydrolysis and subsequent re-N-acetylation, as exemplified in the chemical modification of the Forssman glycolipid and the examination of the immunochemical activities of the products obtained (E. Umeura, *et al.*, Shinshu and Matsumoto) and (b) hydrazlinolysis of the alkali stable oligosaccharides of red cell membrane (Lisowska, *et al.*, Polish Academy of Science, Warsaw).

Iseki has continued his studies on the action of glycosidases on glycoconjugates isolated from erythrocytes, demonstrating the possibility of destruction of H specificity with the fucosidase from *B. fulminans*, B specificity with an enzyme from *Cl. sporogenes Maebashi* and finally A specificity with an enzyme from pig liver. In the latter two examples, this destruction of B and A specificity was accompanied by the development of blood group H cross-reactivity.

Ken Furukawa (Gunma U., Maebashi) a former student of Iseki who also has been largely involved in studies of the enzymatic destruction of blood group substances, devoted himself in this symposium to the description of the reverse reaction, namely the biosynthesis of the B specificity from O erythrocytes with the assistance of α-galactosyl-transferase from saliva.

These interconversions of the antigenically important blood groups involve the nonreducing terminal sugars which are α linked, and are usually difficult to synthesize chemically. So whenever such a method is described or discussed, it always attracts a lot of attention. The presentation by R. R. Schmidt and Hermentin (U. of Konstanz, Germany) was no exception. Likewise, the step-wise synthesis of a serologically H-active tetrasaccharide (Jacquinet, J. C. from U.E.R. de Sciences Fondamentales, et Appliques, Orleans, France) was of interest to many.

Analytical data are necessary prerequisites to good structural studies, and there is constant need for sharpening our tools. Yamanaka (Kagawa U., Japan) discussed the use of specific dehydrogenases for the determination of sugars, more especially fructose, L-fucose and D-arabinose. Yamaguchi, H. (University of Osaka, Japan) utilizing the well-known fact that reducing saccharides are retarded by strongly basic ion exchange resins to separate them from the corresponding alditols in an analysis he wished to carry out on oligo- and polysaccharides.

The "peeling reaction" has always been considered an undesirable accompaniment to any analytical procedure that involves the use of alkali. In the method developed by Takagi, M. (University of Osaka, Japan) employing alkali this "peeling reaction" gives rise to specific dicarbonyl compounds. These immediately react with the O-phenylene diamine in the reagent to give a stable quinoxaline derivative specific for the glycosidic linkage involved. The quinoxalines can be separated on Dowex 1 x 8 and detected by absorbance at 320 nm. From the data obtained, it is possible to determine the chain length of the cleaved oligosaccharides.

And that now brings us to our contribution to the Symposium in which I (Aminoff, University of Michigan) discussed the present state of our art in the specific cleavage of the O-glycosyl-glycoproteins by the β elimination reaction. The value of the method and some of its present limitations as a quantitative procedure were enumerated.

Interest was expressed in the procedure both during the discussion of the presentation and subsequently in various encounters. The greatest number of queries centered on the conditions of assay to optimize the quantitative yield of oligosaccharides and its potential applicability to the diverse glycoproteins with which the investigators were specifically interested. Some of the most common questions were, "Did the N-glycosyl glycoproteins also react, and to what extent?" "Are you working on a method for estimating the oligosaccharides in glycolipids?" Etc.

Those that were aware of my research interests also wondered whether I had our oligosaccharase pure enough to cleave the O-glycosyl bond of glycoproteins enzymatically for subsequent biological studies. Surprisingly, while there was interest expressed in our project regarding the use of glycosidases to change the blood group specificity, nobody perceived the implications of the use of these enzymes to obtain a Universal Blood Donor.

Great interest was expressed by colleagues in our experiments with the viability of erythrocytes in circulation and the factors that might be involved in the clearance of the asialo-erythrocytes from circulation. Indeed, a colleague and competitor in the area, Dr. R. Schauer from West Germany, has been working along parallel lines and while he has shown the specific interaction of the asialo-erythrocytes with the cells of the liver and spleen at the tissue level, we have been able to demonstrate it at the cellular level with both the Kupffer cells of liver and spleen mononuclear cells. We have agreed to publish our findings together in consecutive papers of the same journal.

These represent the major pieces of information relevant to the areas of my research projects. There were, of course, a multitude of seemingly unconnected fragments of information that defy any logical attempt to record them or to put them in proper perspective. Suffice it to say that the value of a Symposium such as this is not only in the written abstract or oral presentation, but also in the multitude of these fragments that are exchanged in the informal discussions. And with all due apologies to the responsible Psalmist, "The rejected stones of yesteryear may well be the cornerstone of some future thoughts."

Unfortunately, the stay in Japan was too short and did not allow for many visits, especially with most of the host scientists themselves on vacation. I did, however, take up the offer of a young Japanese scientist to visit his labs in a Soya Sauce factory in Kyoto. He was an employee in the research laboratories of this factory and surprisingly was working on sialidase and preparing pure sialic acid from colominic acid. Moreover, he used the colominic acid to induce the production of sialidase. Well aware of my work in that area, he sought me out to discuss his work. I was quite impressed by how much can be accomplished with so little.

While in Taipei, Taiwan, I visited the Institute of Biochemistry, College of Medicine, National University of Taiwan, where I had the opportunity to talk to a number of the faculty professors and assess the type and

quality of work carried out in their laboratories. Though not directly connected with our work, there was a tangential interest in their investigations.

In Honolulu, Hawaii, I visited the Department of Biochemistry and Biophysics at the University of Hawaii. I was fortunate to meet with Prof. Yasunobu and one of his students and explore some future aspects of our work relevant to the protein core of the blood group glycoprotein substances.

HITACHI RESEARCH LABORATORY

George Sandoz

The Hitachi Research Laboratory in Hitachi is one of six large research laboratories of the company, all of which report directly to the President and Board of Directors. The Hitachi Research Laboratory (HRL) became an independent laboratory in 1939 and in 1962 the present main building was constructed on the Mikanohara Plateau, a beautiful site which overlooks the Pacific Ocean to the East and mountains to the West.

Dr. Toshio Doi, Deputy General Manager, first outlined the organization of HRL and described briefly also the other five major laboratories. The other five laboratories are:

1. Central Research Laboratory (Tokyo)
2. Mechanical Engineering Research Laboratory (between Hitachi and Toyko)
3. Atomic Energy Research Laboratory (Kawasaki)
4. Production Engineering Research Laboratory (Yokohama) and
5. Systems Development Laboratory.

The total number of people working in the six laboratories is about 4000. The Hitachi Research Laboratory employs 1600.

The research fields covered at HRL include energy, information processing and control, industrial machinery and transportation, and environmental control. Materials research is related mostly to heavy electrical machinery. A close relationship with the company manufacturing works is maintained to assure feedback and prompt application of research results. In fact, HRL maintains branch laboratories at eight of the various works to assure close liaison. The various Works sponsor 75 percent of the research; the remaining 25 percent is sponsored by the corporate head office. Hitachi spends 200 million dollars a year on research and development, with about 30 million of this going to HRL.

Brief introductions to the Fifth Department and the Third Department were given by S. Kirihara, and S. Kusumoto, respectively Senior Researcher in the Fifth Department and Manager, Third Department. These Departments are the two which were visited, although there are approximately 11 Departments at HRL covering materials aspects in the electrical, mechanical, materials, nuclear and environmental areas.

The Fifth Department is active in a number of areas concerned with metallurgy and welding, as follows:

1. Corrosion resistant materials – problems of stress corrosion cracking in stainless and other steels for steam and water turbines and nuclear power plants.
2. Heat treatment of structural materials – heat treatment for structural improvements as well as surface treatments and coatings.
3. Functional materials – these are electrically conducting, superconducting and contact materials.
4. Welding
5. Physical metallurgy – ultrahigh strength maraging steels.
6. Weldability – the weldability of alloys as contrasted to welding techniques.
7. Forging and casting – applications for water and steam turbines, large and heavy forgings and castings.

Several achievements were cited for the Fifth Department. First a multifilament Nb_3Sn superconducting material has been developed. The diameter is 0.74 mm and consists of seven strands, each with 331 fine ($\approx 8\mu m$) niobium filaments, embedded in a copper and bronze mixed matrix. Each niobium filament has an Nb_3Sn filament of about $1\mu m$ thickness at the surface developed by the selective diffusion method. Good features claimed are:

1. instrinsic stabilization
2. bendability and
3. low electric resistance at low but not superconducting temperatures from the mixed copper-bronze matrix.

A second accomplishment is the development of 300 kg/mm^2 maraging steel. There was no specific discussion of this, but several papers were given relating to strengthening by control of

1. solution treatment (JIM *62* No. 8 59, 1976),
2. grain size (JIM *62* No. 2, 56, 1976), and
3. cold working and aging (JIM *62* No. 9, 101, 1976).

The third achievement cited was the high abrasion-resistant Al-Si alloy. This alloy combines the strength of duralumin with greater abrasion resistance. The alloy is formable, weldable (TIG and MIG), machinable and resistant to SCC in solutions containing chloride ions. No reference works were obtained, but Hitachi has produced brochures.

The fourth achievement is the extension and application of fracture mechanics to production machinery. A series of papers by S. Kusumoto and others develop critical analysis and evaluations of the stress intensity factor, including the development of the three-dimensional stress intensity factor by the finite element method (see JPHN *13* No. 6 1975; Proc. 1974 Symposium on Mechanical Behavior of Materials, Kyoto; Proc. JSME-ASME applied Mechanics Western Conference, March 1975, Honolulu).

The fifth accomplishment cited is the development of various welding techniques and their applications. These are deep-penetration electron beam welds, electroslag welds and the soldering of microelectronic components. A series of papers dealing with electron beam welds appear in JIM *43* 32, 1974; JIM *44*, 33, 1975; Proc. Second International Symposium, JWS, Osaka, 1975. The latter reference also includes papers on problems and improvements in large heat input electroslag welds.

The main subjects of interest to the third department, as outlined by Mr. S. Kusumoto fall into three areas. Area one is strength of materials, vibration and noise. Area two is rolling mill control and area three is robots for welding and painting.

Area one includes the structural integrity of nuclear power plants. This involves a three-way thrust at:

1. non-linear stress analysis and fracture mechanics,
2. X-ray stress analysis and fractography, and
3. the creep fatigue, stress corrosion cracking and delayed hydrogen cracking of structures.

Structural reliability of rotating machinery involves similar concerns, but with greater emphasis on vibration problems and less on environmental effects. The structures of interest are pipes, pressure vessels, runners and castings for water turbines, coils, tanks and cases for transformers, elevator and home appliance structures.

A number of papers were discussed which document the work being done. Brittle fracture characteristics of weld joints in 60 kg/mm^2 and 80 kg/mm^2 steel are described in one series of articles by S. Sasaki and coauthors (see JWS *45*, 56, 1976; JWS *44*, 54, 1975; JWS *44*, 47, 1975; JWS *44*, 22, 1975). The same group has published on the effects of prestrain on the fracture toughness of S35C steel, a steel used for mill roll working table rollers (JIM *62* 93, 1976).

A whole series of papers have been written on welding cracking problems: "Effect of Weld Heat Impact on Weld Cracking and Restraint Stress" (IIW Doc IX-957-76), "Effects of Restraint Stress on Delayed Cracks in Welds of 80 kg/mm^2 High-Strength Large Gauge Plate Steel" (IIW Doc IX-735-71), "Effects of Restraint Steress and Intensity of Restraint on Delayed Cracks in the Welds of 80 kg/mm^2 High Strength Thick Plate Steel" (IIW Doc IX 784-72), "Effects of Restraint Intensity on Delayed Cracks in the Welds of High-Strength Steel" (IIW Doc IX 346-73), "Determination of Preheating Temperature for Crack Prevention for High Strength Steel Weld" (IIW Doc IX 875-74), and "Studies of Delayed Crack in Welds of High-Strength Steels – Correlation for Method of Various Weld Cracking" (IIW Doc IX 956-76).

An equally impressive series of papers has been written by H. Ouchida, Chief Engineer, HRL, with several coauthors on the subject of fatigue in pressure vessel materials with cracks and without cracks and in the welded zones. Without attempting to list all these papers, the interested reader is referred to Bulletin JSME 18 No. 119, May 1975; JWS *17*, 1975; JSME *18* No. 125, Nov. 1975; JSME, *17* No. 103 Jan. 1974.

In the nuclear field Kutsumoto and others have presented papers on internal pressure fatigue rupture of the fast reactor fuel cladding (Type 304) and on the effects of hydrogen content. temperature and crack configuration on fatigue crack propagation and unstable fracture in Zr-2.5Nb pressure tubes. Both papers were presented at the 2nd International Conference on Structural Mechanics in Reactor Technology, Berlin, 1973.

Y. Nakagawa and T. Tamamura studied the effect of steel hardenability on the residual stresses developed during heat treatment and reported a significant effect (Proc. 1973 Symposium on Mechanical Behavior of Materials, 1973, Society of Material Science, Japan).

In connection with residual stress determinations, discussion with M. Nagao on a white X-ray system for measuring residual stresses was interesting. Claims for the system are generous. These are for the non-scanning white radiation machine as follows:

1. Short time exposures of 3-4 minutes are sufficient. Inaccessible surfaces such as at the roots of gears can be reached.
2. All varieties of metals can be measured.
3. High temperatures (to 500°C) are permitted.
4. X-ray fractography can be performed. A high intensity beam can be generated which penetrates to the depths of the plastic zones. It is therefore possible to study the history of a fatigue crack, looking at the fracture surfaces.

For example the number of cycles can be determined.

This development has been described in several papers, along with several special applications. This development may be important so a few of the key papers are listed, as follows:

1. N. Nagao and V. Weiss (Syracuse University), "X-ray Diffraction Study of Low Cycle Fatigue Damage in Plain Carbon Steel," ASME paper No. 76-WA-Mat-10.
2. H. Ohuchida, A. Nishioka and M. Nagao, "X-ray Detection of Fatigue in Corrosive Environment," Thirteenth Japan Congress on Materials Research-Metallic Materials.
3. H. Ohuchida, T. Iwasaki and M. Nagao, "Size Effect on Fatigue of Annealed Carbon Steel (X-ray Investigation on the Detection of Fatigue Damage in Machine Parts)," Proc. 14th Japan Congress on Materials Research, Kyoto, 1 1971.

4. M. Ogasawara, M. Adachi, M. Nagao and Voker Weiss (Syracuse University), "Crack Initiation at Notches in Low Cycle Fatigue," Proc. 1973 Symposium on Mechanical Behavior of Materials, Japan, 1974.
5. H. Ohuchida, A. Nishioka and M. Nagao, "Size Effect on Fatigue Strength of Machined Carbon Steel (X-ray Detection of Fatigue Damage in Machine Parts)," Bull. JSME *16* No. 94 Apr. 1073.
6. M. Nagao, S. Kusumoto and Y. Ito, "Non-destructive Sub-surface Distribution Measurement of Physical Quantities – an Application of Poly-chromatic X-ray Technique," Society of Materials Science *26* No. 280, 18, January 1977.
7. A detailed description of the polychromatic X-ray stress analysis system is presented in the Proc. 25th Sagamore Materials Conference, 1976, U.S.A.

The tour of the HRL revealed the usual equipment which has become familiar in tours of a series of steel companies, ship building companies and electrical companies. The concerns are with welding, fracture (especially in large sections), corrosion, corrosion fatigue cracking and fatigue cracking. Taking the tour in order, the following were seen:

Corrosion tests for the BWR plant. Five loops are available. One loop tests SCC under various conditions of flow (0-3 1/min), temperature (to 300°C) and percentage of oxygen in the water (0-36 ppm). Another loop tests for general corrosion. Other loops introduce variables such as temperature, pH, the proportions of oxidizing and reducing species, and differential pressure. One system tests for general corrosion in high temperature water and the effects of electrochemical potential on this high temperature corrosion.

The usual 1000 ton machine for study of low-cycle fatigue was seen. Tests are being run at 1/3 scale, 3-5 cpm, up to 20 kg/mm^2. The current tests are for water turbine components. A 2800 ton test rig is used to study delayed fracture in welds, lamellar tearing, hot cracking and stress-relief cracking. The same rig tests for defect influences and fracture toughness in brittle fracture. A rigid restraint weld cracking tester measures the stresses developed in welds; the capacity is 400 tons.

The high temperature laboratory has over 140 creep testing machines. Under test are superalloys and other high-temperature alloys. One machine has a capacity of 50 tons at a temperature of 1380°C. This machine is engaged in tests of Cr-Mo-V steels and stainless steels. Creep-crack growth type tests with fracture mechanics type specimens are underway. Low-cycle high temperature tests are also going on. The interaction of static and dynamic fatigue is a subject of current study. The available equipment can provide a variety of fatigue-creep load configurations. Tests can also be conducted in liquid metals.

Stress-corrosion tests of 4" diameter welded pipe were described. These tests are almost identical to tests going on (and described previously) at Toshiba Electric Company. Basically the tubes contain water at 290°C and 70-75 kg/cm^2 pressure. Welds of the pipes are introduced. The pipes are tested in tension and in 4 point bending, and in fatigue. The material is 304 stainless steel.

The general impression is that HTL is a truly first-class laboratory. Only a fraction of the activity could be flavored in a one-day visit, but enough could be seen to confirm the excellence of the organization. Fortunately, there are obvious interactions with the USA underway, notably with Syracuse University. The interaction of Hitachi with the Office of Naval Research is certainly worthy of increased emphasis.

PRODUCTS RESEARCH AND DEVELOPMENT LABORATORIES NIPPON STEEL CORPORATION

George Sandoz

There are three central laboratories in the Nippon Steel Corporation which report directly to the President via a Research and Development Bureau. These are the Fundamental Research Laboratories, Products Research and Development Laboratories and the Process Technology Research and Development Laboratories. In addition there are research laboratories associated with each of the ten works located throughout Japan (Oita Works, Nagoya Works, Muroran Works, etc.). Reported here is a visit to the Products Research and Development Laboratories in Sagamihara City, Kanagawa Prefecture, near Tokyo.

The Products Research and Development Laboratories (PRDL) are divided into two departments, the Research Department and the Welding Research Center, both of which report to the Director, Dr. Teruo Ikeno. The Research Department is directed by Dr. Shogo Kanazawa. Five laboratories are in this department, and there are two service groups. These laboratories perform research in the areas described below:

1. Laboratory I – This laboratory is the thin steel and surface treatment facility. Major interest is in coatings of tin, zinc, chromium, etc. particularly as related to the canning industry. Substitution of an electroplated chromium coating as a substitute for tin is a current goal.
2. Laboratory II – This group does application research on thick plates and alloy steels. Studies are conducted on corrosion (wet and dry), corrosion fatigue, fracture and weldability. The group develops new alloy steels such as ferritic stainless steels. Applications in mind are plates for ship hulls, bridges and pressure vessels (both conventional and nuclear).
3. Laboratory III – This group works on forming of welded joints and rods. Finite element methods are coupled with critical experiments.
4. Laboratory IV – Application research on pipes is the major activity of this group, particularly line pipes for gas and oil and the problems which develop from low-temperature service. Nippon Steel makes some of the largest pipe in the world (48 inch) and the Oita Works produces plate 18 feet wide for forming and welding into pipe. Seamless pipe up to 16 inches in diameter is also produced and is intended for OCTG (Oil Country Tooling Goods).
5. Laboratory V – This is an analytical group. New techniques are explored for microchemical analyses and local chemical analyses, as of inclusions.

The Welding Research Center, which is only a few years old, is organized into four main research departments, as follows:

1. Welding Laboratory I – This group works to adapt existing welding equipment to special welding problems which emerge with new applications.
2. Welding Laboratory II – This group works to develop new types of welding equipment and techniques, and also develops NDT equipment (X-ray and ultrasonic). Areas of special achievement have been in automatic welding, narrow – gap electron beam welding and automatic scanning NDT (nondestructive testing) of welded joints in pipelines.
3. Welding Laboratory III – In this group the metallurgy of welding is studied. Included are studies of fluxes for submerged arc welding and the study of the fundamentals of metal-flux interactions.
4. Welding Laboratory IV – This group works with subsidiary companies to develop compatible plate-welding technique-welding material systems. It is common for the purchasers of steel to include the welding package in the deal, and Nippon Steel then assumes responsibility for the quality of subsidiary weld material producers.

The Welding Research Center also runs a Welder Training Center for companies using Nippon Steel plates and welding materials. Over 6000 engineers have graduated from the one to six month course.

Following the introduction to the organization of PRDL, a tour of the facility was arranged with N. Taniguchi, an outstanding Senior Research Engineer. The tour revealed some of the most advanced equipment in the world for welding methods and weld testing. It will suffice, hopefully, to simply indicate the types of tests and equipment which were observed, as follows:

1. In the analytical laboratory, a gas chromatographic method for measuring the hydrogen content in many specimens at the same time was shown.
2. In one laboratory, multiple cantilever beam tests for the hydrogen-charged cracking of welds were underway-Specimens are cathodically charged before test, and the specimens contain a saw-cut notch.
3. Both dead load and hydrostatic weld implant tests are conducted.
4. Patch tests for the study of the effects of high residual stresses are carried out.
5. Lamellar tearing tests and surface strain tests are going on.
6. The Tekken test of the Japanese Railroad Research Institute to measure the effects of preheat and postheat on weld cracking is used.
7. Simulations of the electric resistance welding of pipes are done to study the mechanisms of ERW and improve the toughness of the joint.
8. Both tensile and cantilever beam tests of susceptability to cracking in hydrogen sulfide are done. The concentration of H_2S in the nitrogen environment can be controlled to 10 ppm. Cantilever beam tests are being phased out in favor of the compact tension fracture mechanics specimen.
9. Compact tension fracture mechanics tests are being done to produce data for the Japan DSRV (Deep Sea Rescue Vehicle). One test is underway to see if there are differences in K1scc between 1 inch and 2 inch sections of the 10 Ni-8Co type steels.
10. A very large test cell (room) with humidity controlled at any point between 20 and 95 percent and temperature between -40°C and +40°C is used for testing welding in various atmospheric conditions. For example, tropical environments can be produced.
11. Fatigue test equipment includes a 2000 ton, 6000 cpm servo type Saginamya machine used for tests on welded joints.
12. A high-speed impact machine (30 m/sec, 10 kg) is used to test vehicle safety (e.g., the sides of automobiles).
13. A high energy rate machine is used to test effects of high extrusion rates.
14. Many of the usual brittle fracture tests of welds and fusion lines in plates are conducted. The laboratory features one large machine which can apply 8000 tons static load (second largest in Japan) and 2000 ton cyclic load at 20 cpm. The massive tests are used to test steels for giant new bridges and off-shore platforms, where heavy sections are involved.
15. Lamellar tearing tests are conducted on steels up to three inches thick. Lamellar tearing is a concern in massive welded structures involving heavy sections and rigid constraints.
16. A great number of corrosion-fatigue tests of smooth specimens in synthetic seawater are conducted.
17. A massive dynamic tear test (courtesy of W. S. Pellini and E. Lange of NRL) is in operation.
18. One side, one pass submerged arc welding equipment is available. This is a notable Japanese development.
19. Narrow gap MIG welding equipment (from Battelle) is available.
20. Vertical narrow gap MIG welding equipment is in operation.
21. Simplified electroslag welding involving a fluxcoated electrode is done. The flux is on the outside of a tube, and the weld wire is inserted down the tube. Copper chills as the weld sides are used. Vertical welds 10 meters high have been made by this SES process.
22. A variety of other welding process equipment was seen, including the VASCON, OSCON and MISA processes. VASCON refers to automatic (e.g., vertical up) arc welding processes with voltage and current control. OSCON refers to automatic arc welding processes involving controlled oscillation of the welding wire. MISA refers to submerged arc welding processes using fine wire. A number of other welding processes are in use or under development. Detailed descriptions are available in Nippon Steel brochures and reports.
23. Experiments in weld overlay with stainless steel are being conducted.

The Director of the PRDL, Dr. Ikeno, next reviewed some of the history of the organization. About six years ago he visited the USA to gather background material so that he could better decide what PRDL should work on. The most impressive work in the USA according to Ikeno was being done at U. S. Steel (M. Lightner) and at NRL (E. Lange).

Upon returning to Japan, Ikeno organized his laboratory along the lines of the (former) U. S. Steel Laboratory at Monroeville. The new philosophy was that it is not enough to simply produce steel products any more. Steel will be used in even more massive structures, at higher and lower temperatures, and in new and more corrosive environments. The steel company should therefore get involved in anticipating the requirements of the user, both present and future, so that a satisfactory product will be available when needed. It is for this reason that so many diverse facilities have been assembled at PRDL. Another feature is that all types of materials people are brought together in one laboratory, providing the multidisciplinary approach to critical problems.

Examples of the problems the laboratory gets involved in are the Alaska pipeline, the North Sea offshore structures, and the construction of tanker ships up to one million tons. The requirements of this service are fed back to the laboratory which then strives for solutions. The Alaska pipeline difficulties, for example, could be attributed to the use of untrained welders (due in part to union pressures). The problems were solved by developing an automatic girth welding system and automatic inspection – recording devices.

The girth welding procedures have been offered to the Canadian Gas Line Study Limited, presumably as an inducement to use Nippon material. Nippon Steel has apparently developed some H_2S resistant steels which would be a further attraction. There was no discussion of the features of these H_2S resistant steels.

Dr. Ikeno stressed that cooperative, world-wide research would be welcome, and that Nippon Steel Company would exchange information freely in such efforts. He would appreciate being contacted by any interested organizations or individuals.

From discussions of specific research activities, several areas of interest emerged, as follows:

1. Lamellar tearing – this process, referred to previously, is of concern in heavy section welded components and structures. Investigations, principally by Dr. S. Kanazawa, have been conducted on an assessment of lamellar tearing susceptibility of steel plate (IIW Doc. IX-840-73) and on lamellar tear resisting steels and how to use them (IIW Doc IX 873-74). As might be expected, lamellar tearing may be reduced by improved desulfurization and rare earth metal additions.
2. Studies of fracture initiation in normalized and cold-worked mill steels and the related effects of grain size on this process. This work is due to M. Ogasawara, M. Iino and H. Mimura (Trans JIS *11* No. 1 1970, JIS *12* No. 4 1971 JIS *13* No. 1, 1972). Transition temperatures were lowered with cold work and decreasing grain size.
3. S. Kanazawa reviewed the use of vanadium to improve properties, particularly weldability, of high strength steel at the Vanitec Meeting of 1976.
4. The development of new steels for high heat input welding was described also by S. Kanazawa (IIW IX-952-76). Welding fusion zone toughness is improved by fine tin particles.
5. S. Kanazawa and others have written on problems of stress-relief cracking in high strength steel and stainless steel. Cracking is located at the prior austenitic grain boundaries. Effects of alloying elements are given (see Trans JWS Vol. 7 No. 1 1976).
6. Several PRDL investigators, S. Kanazawa again principal author, described at the 2nd International Conference on Materials in Boston, August, 1976, the fracture safe design of welded steel structures base on large scale tests.
7. Reports by S. Kado and others, appearing in July, 1975 (IIW Doc. XIII-771, 772, 773-75) describe improvements in the fatigue strength of welds through TIG dressing and by additional weld runs with coated electrodes. The dressing appears to improve weld-toe configurations.
8. N. Taniguchi and others presented papers on "Dynamic Transition Behavior of Structural Steels" and "Modified Three Point Bend Test for Determining Brittle Fracture Properties" at the March 1977 International Conference on Fracture Mechanics and Technology in Hong Kong. The feasibility of using a sharp machined slot in the DT test instead of the Ti-electron beam crack starter is argued for steels up to strength level HT90.

9. S. Kanazawa and N. Taniguchi submitted a paper on "Effects of Crack Tip Damage on K_{1SCC} with 4340 Steel" to the 3rd ICF in Munich. The conclusion is that fatigue precrack loading levels can have a significant impact on the values of K_{1SCC} which are subsequently determined.

In general, the PRDL appears to be a well equipped and well staffed laboratory. The work going on is very impressive and could be a model for other steel companies in the world which may wonder at the success of Nippon Steel.

FUNDAMENTAL RESEARCH LABORATORIES
NIPPON STEEL CORPORATION

George Sandoz

The Fundamental Research Laboratories of Nippon Steel Corporation is one of the three "corporate" laboratory groups which report to the President via a Research and Development Bureau. Other laboratories are in existence within the company, but these are associated with the various Works which are found throughout Japan.

The Fundamentsl Research Laboratories are located in Kawasaki City. The two other "corporate" research laboratories are the Products Research and Development Laboratories (also visited) in Sagamihara City and the Process Technology Research and Development Laboratories in Kitakyushu City, Fukuoka.

The Director, Dr. Shin-ichi Nagashima first described some of the history, organization and functions of the Fundamental Research Laboratories (FRL). The laboratories began as the Tokuo Research Institute of Yawata Iron and Steel Institute, Ltd. Nippon Steel, formed by merger to include Yawata Iron and Steel Co., was established in March, 1970, and in November, 1970, the present FRL was organized. There are about 270 persons employed of whom about 60 percent are professional level. Thirty-one, or about ten percent hold doctorates.

The laboratories are organized according to eight functions, as follows:

1. Fundamental Research Laboratory I – Strength and toughness.
2. Fundamental Research Laboratory II – Workability and plasticity.
3. Fundamental Research Laboratory III – Corrosion and heat resistance.
4. Fundamental Research Laboratory IV – Raw materials and iron making.
5. Fundamental Research Laboratory V – Refining and solidification.
6. Fundamental Research Laboratory VI – Coating and new materials, including composites.
7. Measurement Research Laboratory – Measurements and development of new research procedures.
8. Analysis Research Laboratory – Chemical and instrumental analysis.

With these groups the laboratory performs the more long-term, future oriented, research of the corporation. It was stressed, however, that they interpret the word "fundamental" to mean purpose-oriented, high-potential research. The similarity to the ONR mission is apparent, except that ONR has a greater variety of "purposes."

A tour of FRL, conducted by Dr. T. Murata, Senior Research Metallurgist, was necessarily short because of the time needed for discussions. A variety of automated analytical equipment developed by FRL for such elements as P, Si, Mn, N, and O was observed. Auger analyses are conducted, and a device to fracture samples within the system avoids contamination of the surfaces before analysis. Samples can also be fractured within the Auger system at elevated temperatures. This is useful in studies of hot ductility and temper embrittlement in which contaminants may segregate at elevated temperatures.

The high point of the tour, however, was the one million volt electron microscope. The microscope which of course provides good resolution is also equipped with devices to heat and/or deform specimens in gas atmospheres up to 20-50 torr. Thus the generation and movement of defects produced by these forces can be observed directly. A taped movie of some previous observations was shown. One could see the movement of dislocations as iron is deformed. As temperature increased, transformation to austenite was seen. A particle of cementite was observed to dissolve, and the carbon diffused along a dislocation. This is a spectacular movie indeed.

Two achievements of note are in the refining and metal reduction field. Very pure stainless steels and ferrochromium alloys have been made with a process called metal bearing slag refining (MSR), developed at FRL. The level of phosphorus in both ferrochromium and stainless steel can be reduced to 5 ppm by this process. The process is not in pilot plant stage.

FRL is producing amorphous metal alloys by splat cooling and is looking at the possible fields for application. The excellent corrosion resistance is considered an important attribute. Laser beams are being used as a power source for welding, and laser processing techniques to produce amorphous structures are under consideration. There were no discussions about particular welding applications of lasers.

The individual researchers at FRL are engaged in a wide variety of activities. H. Okada, Y. Hosoi and S. Abe have been studying stress corrosion cracking of austenitic stainless steels, and in particular the role of metal dissolution during SCC in chloride solution. Fractographic observations of the crack surfaces have been made. Type 304 and 310 stainless steel fractured transgranularly in boiling $MgCl_2$ (143°C). Intergranular fracture was found in type 316 stainless. Intergranular fracture was favored by increasing percentages of Mo, applied stress increases and lower test temperatures. Also, according to these authors, Fe and Ni dissolve during SCC, but Cr does not. A mechanism of cracking based on successive metal slip and metal disolution at the fresh slip faces is proposed.

Okada and others have been active in international conferences such as the recent USA-Japan Conference on Passivity and Its Breakdown on Iron and Iron Base Alloys. Okada was co-editor with ONR contractor R. Staehle of Ohio State University of the proceedings of this conference. Among the several papers presented by FRL investigators were analytical studies of passive films by Auger analysis, studies of the transitions in fracture modes as related to the environment and compostion, and studies of the cathodic reactions at fresh surfaces after mechanical rupture and the effect of phosphorus thereon. One important conclusion was that phosphorus increases the hydrogen evolution reaction at fresh surfaces of stainless steels at low pH. Chloride ions mask the effects of hydrogen, but not at high strain rates; thus, copious quantities of hydrogen may occur at crack tips. These results lend increased significance to the efforts of FRL in developing the new metal bearing slag refining process (MSR) which promises the production of stainless steel of extremely low phosphorus content.

Okada and H. Shimada have also studied the formation of rust on cold rolled sheet (Corrosion *30* No. 3, 1974). Maganese sulfide was confirmed as the source of rust initiation. In water α – (Mn, Fe) S dissolves most readily if the solution contains oxygen. In humid air at 60°C the rust formation process is concluded to be:

1. dissolution of some α-(Mn, Fe)S,
2. precipitation of fine colloidal particles of $\gamma - Mn_2O_3$ (Mn_3O_4) around the α-(Mn, Fe)S particles and
3. the initiation of rust around the fine γ-Mn_2O_3 (Mn_2O_4) particles.

Valuable summaries of the corrosion behavior of steels and weldable steels have been produced also by FRL (Nippon Steel Technical Report Overseas No. 8, May 1976).

Dr. M. Nagumo reports some interesting results on the tensile fracture processes of perforated mill steel sheet (Acta Met. *21*, 1661, Dec. 1973). Fracture did not take place by hole coalescence but rather by the initiation of a shear crack at the side of a hole. Comparison of the plastic strain energy associated with the growth of a hole with the plastic strain energy for shear cracking produced a criterion for the onset of a shear crack. This criterion proved to be applicable to predicting the effects of spherical inclusions.

Creep-rupture studies on Inconel 617 at 1000°C in helium have been studied by Y. Hosoi and S. Abe of FRL (Met Trans. vol. 6A, June 1975). Oxygen diminishes creep-rupture times by decarburizing the steel. These authors were very aware of the work of Dr. P. Shahinian of NRL, and were interested in hearing of Shahinian's latest activities.

O. Kommori and others have studied the isolation and chemical analysis of inclusions in steels. A paper was presented on this subject to the 1976 Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, March 2, 1976 (see also JIM *12* No. 2 1971).

Another achievement at FRL is the development of a Co-free Ni-base superalloy for the HTGR by Y. Hosoi, N. Shinoda, T. Tsuchida and M. Sakakibara. The alloy is composed of 18 Cr 15W and 0.5 Mo, with small additions of Y and Zr for improved creep strength. In helium the alloy meets the required creep rupture strength of 1 kg/mm^2 for 10^5 hours at 1000°C.

N. Nagumo and T. Takahashi presented a paper on "Hydrogen Embrittlement of Some Fe-Base Amorphous Alloys" at the Second International Conference on Rapidly Quenched Metals at MIT, Boston, Nov. 17, 1975. Interesting features of the hydrogen embittlement of amorphous metals (from cathodic charging) are that the Cr in the Fe_{70} Cr_{10} $P_{13}C_7$ alloy contributes to the high corrosion resistance and minimizes hydrogen permeation. When hydrogen embrittlement is observed, it proves to be completely reversible. Finally the authors indicated that the diffusion rates of hydrogen in amorphous alloys are lower than in crystalline alloys.

M. Nagumo has prepared a paper, "Initiation of Cracks at Delayed Fracture of a High Strength Steel" for presentation at the 4th International Fracture Conference, Waterloo, Canada, June 1977. An acoustic emission technique shows incipient cracking at inclusions and grain boundaries at the roots of stressed notches. The threshold stress for cracking of stressed cathodically charged specimens is reduced by soluble nitrogen, and an interaction between soluble nitrogen and hydrogen at grain boundaries is proposed. Increasing soluble nitrogen also produces a change in fracture mode from transgranular to intergranular.

The FRL is engaged in a multitide of other research efforts, such as coating, plating and blast furnace technology, but the above descriptions hopefully indicate the flavor and thrust of FLR.

The overall impression is that this is a first-class laboratory with an eye to the future. The laboratories of Nippon Steel are certainly the equal of comparable laboratories in the world which have been observed. The scientific leaning of the laboratories coupled with the continued commercial success of the corporation suggest that perhaps science and profitability are compatible after all.

TOSHIBA RESEARCH AND DEVELOPMENT CENTER

George Sandoz

The Toshiba Research and Development Center in Kawasaki was organized into its present form in 1961. There are approximately 1680 employees at present (double the number in 1961) of whom about 800 are professional level, and 100 hold doctorates. The center is composed of ten specialized laboratories. The laboratory visited was the Metals and Ceramics Laboratory, which is grouped into (1) electric and magnetic materials, (2) structural materials and (3) ceramics and glasses. Other laboratories are concerned with chemicals, electron devices, integrated circuits, electronics equipment, information systems, consumer products (appliances, radio), nuclear and electrical engineering, mechanical engineering and microwave electronics.

The Metals and Ceramics Laboratory, under the direction of Dr. Y. Yoshida, is divided into six sections. The Electric and Magnetic Materials group is concerned with magnetic, superconducting and electric materials. The Structural Materials Group is concerned with corrosion resistant metallic materials, high temperature metallic materials, fiber reinforced composite materials, powder metallurgy and nuclear reactor materials. Stress corrosion cracking is a serious concern of this group at present. The Metal Processing and Evaluation Group evaluates materials and their processing and control. The Special Ceramics Group looks at ceramics for high-temperature applications and as ionic conductors. The Glass Group studies glass fibers for optical and electronic communication as well as glass manufacturing processes. Finally, the Electronics Ceramics Group studies ferrites, piezoelectric materials, nonlinear resistors, surface wave materials and the processing and manufacturing of these materials.

The visit began with a historical overview of the organization by Dr. S. Chiba, substituting for Dr. Y. Yoshida who was in the United States at the time of this visit. A brief movie was shown which indicated activities of the organization in the area of water purification (by ozone), ultrasonic diagnostics, ion implantation, light emitting diodes, silicon solar cells and in the development of the so-called "silentalloy." The latter is an iron-base alloy with unusually large damping capacity and is useful where noise and vibration must be suppressed.

Individual discussions followed a presentation on NRL-ONR interests. Mr. M. Hishada discussed some of his work on stress corrosion cracking of stainless steels. He is studying the corrosion of type 304 stainless at constant strain rate (8.3×10^{-7} to 10^{-5}) in high temperature water (209°C). According to Hishada, an accelerating environment such as boiling magnesium chloride is not predictive in the case of high temperature water and therefore the autoclave tests are necessary. The results indicate that stress corrosion cracking takes place only when two conditions are satisfied: the water must contain dissolved oxygen and the steel must be sensitized. Either condition alone does not produce cracking.

Hishada has recently spent a year in the United States studying with ONR contractor R. Staehle at Ohio State University. Three papers by Hishada (with H. Nakada) have been submitted to NACE entitled, "Constant Strain Rate Testing of Type 304 Stainless Steel in High Temperature Water," "An Investigation of the Chloride Effect on Stress Corrosion Cracking in Constant Strain Testing of Type 304 Stainless Steel in High Temperature Water," and "Critical Cooling Rate of 18Cr-8Ni Stainless Steel for Sensitization and Subsequent Intergranular Stress Corrosion Cracking in High Temperature Water."

Mr. I. Watanabe described current work on the carbide reactions in heat-resistant steels. He hopes to relate microstructural observations to predictions of life and residual life of materials in high-temperature service. Specifically, he is trying to estimate (1) the effects of carbide spacing and size on creep rates and (2) the effects

of solid solution strengthening of the matrix, as this is influenced by the effects of alloying elements in the matrix on carbide solubility. The prevention of stress corrosion cracking through studying the means to impede depletion of chromium in the grain boundary region is also under study.

Watanabe studies in situ each carbide particle with respect to composition and local chemistry, using X-ray analytical procedures. Carbide morphology is studied by extraction replica techniques. Watanabe was cautioned that his goals are difficult to achieve. Predictions of long-term performance on the basis of structural features have been less than totally successful.

Mr. A. Tsuge next described some of the company's activities in nitrogen ceramics. The major achievement claimed is a high-strength Si_3N_4 material with a Y_2O_3 additive to promote sintering. A flexural strength of 120 ksi at 1400°C is claimed. The material can also be water quenched from 1000°C without damage. According to Tsuge, the addition of rare-earth elements such as yttria and alumina to silicon nitride (followed by sintering) is the secret. The rare earth additives increase the high temperature strength of the ceramic material by combining with Si_3N_4 to form $Si_3N_4.Y_2O_3$, which is very resistant to heat. The grain boundary phase in the improved materials is crystalline, in contrast to the glassy phases which form with MgO additives. The Y_2O_3 additive also produces a change in fracture mode from intergranular (with MgO) to transgranular at elevated temperatures. The new ceramic is expected to have wide application in gas turbine blades and vanes, heat exchangers for high temperature gas reactors, seals in rotary engines, gas bearings and in crucibles for molten metals. Background material for this development is published in J. American Ceramic Society *58* No. 7-8, 323,1975; J. American Ceramic Society *57* No. 6, 1974; Toshiba Review No. 92, July 1974.

The visit concluded with a visit to the Toshiba Science Institute. This is essentially an elaborate exhibit intended to give the viewer a preview of the electronic world of the future (TV telephones, trains without wheels, etc.). Toshiba seems to be aggressive, alert, working hard, and generally in tune with the latest in technology which applies to its interests.

TOSHIBA HEAVY APPARATUS ENGINEERING LABORATORY

George Sandoz

Under the guidance of M. Arii, Manager of the Plant and Equipment Engineering Department, Atomic Power Division, a visit was made to the Metals Engineering Group of the Heavy Apparatus Engineering Laboratory of Toshiba. Arii was formerly head of the Heavy Apparatus Engineering Laboratory.

The visit began with a tour of the laboratory, located at Tsurumi, Yokohama. The laboratory is composed of several groups. One group studies the techniques for electrical insulation. A second group is involved with metallurgical engineering. Studies of interest involve SEM studies of fatigue striations, acoustic emission, zone refining equipment and TIG welding developed for ultra-high precision parts. A third group is concerned with wastewater treatment engineering. A fourth group is concerned with atomic power equipment engineering. Examples are: mock-up of fuel handling device for fast breeder reactor, electromagnetic pumps for liquid sodium, bellows type vacuum vessels for experimental nuclear fusion devices and mock-up of plasma experimental devices. Another group studies electrical machinery engineering. Featured are an anechoic room, hydraulic vibration machines for earthquake strength tests and large thrust bearing testing equipment. A hydraulic machinery engineering group features a high-head test stand for pump-turbines, a data processor for model tests of water turbines and a 5-axis numerical controlled machine to machine turbine blades of precise configuration.

On the tour an assortment of enormous, impressive equipments were observed, as follows:

1. A steam turbine generator coil winding shop. Generators (steam turbine) to 1000 million watts were seen in production.

2. Direct current motors for shipment overseas, mostly to steel companies were seen in production. These range in size from 700 to 7300 KW. They were destined for such diverse places as Crete, Venezuela and Cleveland, Ohio.

3. A welding shop was seen which produces welded components for water turbines. Stock up to 6 inches thick was being welded from 80 kg/mm^2 steel by electroslag welding.

4. Truly giant water-turbine machinery for hydroelectric power facilities were being fabricated. The water turbines were fabricated of 13 percent chromium stainless steel.

5. Most welding is CO_2 arc welding, but special problems involve MIG, TIG and electroslag welding. A 31 MeV Betatron is used to test welds.

A study of stress corrosion cracking susceptibility of 304, 316, 316C and 347 stainless steels was described. Test sections are 4 inch diameter, 8 mm thickness pipes containing three-welded joints. Loads are either tensile, up to 75 ton, or 4-point bending. The pipes contain water at 75 kg/cm^2 pressure and 290°C temperature. Cyclic loads are used, at a rate of zero to maximum once or twice a day.

Acoustic emission studies are being conducted on large pipe sections which contain a machined notch. The notch, 0.3mm wide, 16mm deep and 19mm wide, simulates service conditions for a feed water nozzle of the BW reactor. Fatigue loads are related to notch extension. The particular test piece observed had endured 100,000 cycles at a rate of 6 or 7 cpm. The acoustic emission detector is a Dunegan Model 1032, obtained from the USA.

A biaxial stress test apparatus and specimen was seen. The specimen is cruciform and costs $3000. A saw cut notch is placed at various orientations within the specimen center. A creep gage is inserted in the notch. The idea is to determine whether the K_{1c}, slip or J-integral criteria for fracture apply to biaxial fracture.

Studies of creep-fatigue interaction are underway, with the goal of supplying essential data for the FBR at 650°C.

Dr. Arii serves with Dr. Iida of Tokyo University in setting up an International Symposium in Tokyo on 25-27 September 1978 on Criteria for Service Fracture of Welds and Welded Structures. This meeting, sponsored by the Japan Welding Society and the Japan Academy of Sciences, will feature welding, metallurgy, identification of defects and in-service inspection.

Individual discussions were arranged on the subjects of stress corrosion cracking of stainless steel, fracture mechanics and the application of high strength steel (HT 80) to the casings of hydraulic pumps. The substance of these discussions follows:

1. Stress corrosion of stainless steel–Toshiba is interested in short term countermeasures to improve welding procedures but is also interested in long term countermeasures for problems which may develop in BWR plants. They are therefore studying stress corrosion cracking in constant strain rate tests and constant load tests and are involved in the pipe tests described previously.

Some principal achievements have been quantitative chemical characterization of sensitization, and the use of flowing water in the pipe during welding (after the first pass) to produce compressive residual weld stresses at the weld inside the pipe (a short term countermeasure proposed by IHI).

Another achievement has been the development of weld cladding prior to butt welding of pipe. The process permits the retention of sufficient delta ferrite to impede stress corrosion cracking and the heat affected zones can be solution treated.

2. Fracture mechanics–This work originated from tests on turbine generator rotor forgings. These were spin burst, deep notch tests and K_{1c} tests. Acoustic emission monitoring suggested that crack growth was not always related to the direction of maximum stress. Tests were therefore conducted under conditions of biaxial stress, as described earlier. The results indicate that indeed both the values of K_1 and K_{11} must be evaluated to get the true fracture resistance, because the flaw growth direction is not always perpendicular to the direction of maximum stress.

3. Heavy thickness high strength steel for pump casings–The primary interest here is for nuclear pumps. The discussions were on the resistance of high strength steels to crack propagation in gaseous hydrogen as well as to other sources of embrittlement.

The substance of the interests of the Heavy Apparatus Laboratory is contained in several publications which have appeared in recent years. Plane strain initiation of brittle fracture in rotor forgings is discussed in Mechanical Behavior of Materials, Proc. of the 1971 International Conference on Mechanical Behavior of Materials, Vol. V, 1972, p. 407. A correlation of fracture toughness by the spin burst and deep notch test is described in Theoretical and Applied Mechanics, *21*, University of Tokyo Press 1973. The fatigue strength of HT 80 spiral castings for hydraulic pump-turbines is given in IIW Doc. XIII-728-74. Slow crack growth and acoustic emission characteristics in the COD test are described in Engineering Fracture Mechanics 7, 551 (1975).

The Heavy Apparatus Engineering Laboratory is obviously current and keenly aware of practical problems and the shortcomings of current laboratory predictive capabilities with respect to crack growth, fatigue and fracture.

FURUKAWA ALUMINUM COMPANY

George Sandoz

Furukawa Aluminum Co., Ltd., is one of the leading aluminum fabricators in Japan. Products are sheet, stranded steel-core wire, castings, forgings and extrusions. The Nikko Works produces sheets and forgings at the rate of 6000 ton/month and 50 ton/month respectively. Products are foils, can sheet, painted sheets, circles, die forgings and free forgings. The company ranks third in Japan in the domestic market for sheets and extrusions.

Furukawa Aluminum Company derives from the Furukawa Electric Company, Ltd., and production began in 1920. In 1959 a cooperative agreement was made with Alcoa Aluminum Company, U.S.A. Technical exchanges are a part of this agreement. At present Furukawa Aluminum Company imports aluminum pig from Alcoa of Australia.

Developmental research activities at Nikko are conducted by 7 metallurgists, 6 chemical engineers and 2 mechanical engineers. Close cooperation with Alcoa permits the staff to focus on research which is important, complements Alcoa research, and is in keeping with Furukawa's capabilities. Five major activities are involved, as follows:

1. Packaging and forming materials–cans, kitchen utensils, fins (for heat exchangers) and foils.

2. Automotive products–body panels for automobiles, automobile wheels, plated aluminum bumpers.

3. Heat exchanger products–vacuum brazing technology and ultrasonic soldering technology.

4. Design and manufacturing of structural products–upgrading of high strength forgings, welding practice and materials, highway fencing materials toughness.

5. Others–electrolytic coloring of Al-Mg-Si alloys, chemical conversion coatings, cold working of Al-Mg-Si alloys, screw machine stock alloys.

Dr. T. Tanaka, Manager of the Technical Research Section, provided a review of the above activities with some special insight as to current emphasis. For example vacuum brazing is being developed to overcome certain hazards involved in flux brazing. Japan was the first to develop vacuum brazing on a commercial basis. Optimization of brazing alloy compositions for vacuum brazing is a current effort. Pitting corrosion and the means to protect from this by cathodic protection are also being studied. Surface finishes and the weld areas are of special interest.

Along with other aluminum fabricators in Japan, Furukawa Aluminum is trying to develop the Al-Zn-Mg alloy 7003 for structural purposes at the strength level 40 kg/mm^2. This alloy, which contains no copper, is also attractive for its good extrudability. Applications for rail coach rolling stock for Shinkansen bullet trains (220-260 km/hour) are seen.

The alloy 7003 is, however, subject to stress corrosion cracking, and rail applications demand a life of 30 years. Furukawa research activities are examining every way to improve SCC resistance–modification of composition, heat treatment and design factors to optimize the application of structural loads. Cantilever ASTM test methods are employed, and consideration is given to directionality.

Furukawa Aluminum produces 7075 T-73 alloys forgings for the F-86 and Phantom for the Japanese Defense Force. Greater strength and toughness are a goal of current research. The company also is involved with forgings for the marine and ship building industry. Examples are pistons, impellors and superchargers. Furukawa can hand-forge to a diameter of 1½ meters. Flanges of this diameter were made for the pipes for LNG tanks. Pistons can be forged which are 52 inches in diameter and 36 inches high. These are for installation in 300,000 ton class tankers.

With respect to welding there is need to weld plate 70-80 mm thick. Rolling stock weldments for trains are also a concern. Problems of special interest are cracking and porosity. The addition of Zr to welding electrodes has been found effective in reducing weld cracking, and the addition of B also refines the structure. Zirconium is also believed to remove hydrogen. Welding rod containing both Zr and B, developed at Furukawa Aluminum, is now commercially available.

Other current problems are the corrosion of aluminum alloy guard rail along coastal areas and the production of Al-Mg-Si alloys for use in baseball bats and in ski equipments. Furukawa hopes to eliminate the annealing operation currently practiced in the U.S.A. In summary, the laboratories at Furukawa Aluminum are trying to widen the applications of aluminum alloys by the general public as well as by defense and governmental agencies.

With respect to specific research activity, research on Al-Zn-Mg alloys commenced in 1960. Production of K-70 (Al-4.5 Zn-1.5Mg) for welded structures started in 1961. Studies of Al-Zn-Mg alloys for welding stock began in 1962, with studies on welding practice and stress corrosion cracking. In 1972 production of the alloy K 73 (Al-5.8 Zn-1.2Mg) for rolling stock, skis and motorcycle frames began. In 1974 the K74 alloy (Al-4.5Zn -2.0Mg) was developed as a high-strength Al-Zn-Mg alloy.

Among the researchers, T. Tanaka and T. Saito have been by far the most prolific. A series of articles describe the stress corrosion cracking problems of Al-Zn-Mg alloys (see Proc. Japan Light Metals Institute: *19* No. 2, p. 55, 1969; *19* No. 8, 327, 1969; *19* No. 8, 336, 1969; *20* No. 7, 327, 1970; *22* No. 6, 403, 1972; *25* No. 6, 214, 1975. The main conclusions of these investigations are as follows:

1. Stress corrosion cracking (SCC) is worse with a narrow precipitate free zone and finer precipitates.

2. Sensitivity to SCC increases with low-temperature aging and prestraining.

3. SCC of sheared edges of welds corresponds to SCC data on plates subjected to external, not residual stresses. Residual stress cracks do not appear at the heat affected zone.

4. Step aging increases resistance to SCC at a given strength level in Al-Mg-Zn alloys.

5. Rolling reduction increases the SCC resistance of 7075-76 alloy plates. Orientation is highly significant. Grain boundaries, especially those lying perpendicular to the direction of stress, play an important roll in SCC of 7075 alloy.

6. Additions of 0.1 a/o of Cu. Cr, Ti or Zn had little effect on the SCC resistance of Al-4.5 w/o Zn, 2.9 w/o Mg alloy.

The overall impression of the Furukawa Aluminum Company at Nikko is that a great deal of important and practical development is being accomplished by an excellent but relatively small staff. The reason for this productivity is twofold:

1. There is profitable interaction with Alcoa research.

2. There is continuous interaction with production people in the plant.

MITSUBISHI METAL RESEARCH INSTITUTE

George Sandoz

The Mitsubishi Metal Research Institute is essentially the corporate research laboratory of Mitsubishi Metal Corporation. In 1976 the Metal Research Institute achieved status as an independent company, but it is evident that organizational ties remain.

Mitsubishi Metal Corporation is a giant conglomerate engaged in material activities which range from mining and raw material production to the science of metal alloy fabrication. The company specializes in nonferrous metals and the smelting and refining department produces metals and alloys of Cu, Pb, Zn, Au, Ag and Sn. The metal fabrication department produces a range of products from nonferrous metallurgical products to industrial machinery and even pigments. The Niigata plant produces, for example, sintered machine parts, oiless bearing alloys, metallic filters, sliding electrical contact alloys for trolleys, and sintered magnetic Al-Ni-Co magnet alloys (Diamet and Diamax materials). The Okegawa Plant produces corrosion and heat resistant Hastelloy, hard facing Haynes-Stellite alloy, high strength bronzes, Monel alloys, chromium-copper conductor material, precision castings, forgings, and silver brazing alloys. The Ooi plant produces tungsten carbide tools, rock drilling bits, diamond tools, dental drill alloys and face mill cutters. The company also produces and processes nuclear fuels and nuclear reactor alloys (for LWR, HTGR and FBR reactors). Zircalloy tubing is produced, for example, in Okegawa.

The Research Institute reflects these wide interests in its research activities. There are groups concerned with ore concentration, chemical and physical separation and purification. A material science group is involved with physical metallurgy, such as electron microscopy to study dislocation loops in creep deformed nickel-base alloys or the microstructure of hot isostatically pressed powders of superalloys. The metals and alloys group studies melting, casting and fabrication of alloys such as nuclear material for NTGR reactors and mold materials for continuous casting. This group also studies the joining of Co, Fe, Cu and Al base alloys by such means as electroslag welding and vacuum brazing. A group is also concerned with coatings and corrosion and stress corrosion of an assortment of alloys. The stress corrosion of nickel base alloys and stainless steels in fuel gases and in molten salts is an example. A powder metallurgy group works on problems of sinter-forging of powder metallurgy materials such as titanium and heat and corrosion resistant nickel-base alloys and friction materials (for disc brakes, railway brakes, etc.). This group also studies the details of wear and fracture processes in cemented carbide tool materials (TiC and WC in cobalt). Other groups work with fine ceramics such as Ni-Cu ferrites for magnitostrictive vibrators (which are claimed to operate well under high pressure), ultrapure materials and semiconductor materials such as GaAs. There are also studies of nuclear fuel and nuclear absorber materials, extractive metallurgy, pollution technology and analytical technologies.

A tour of the Metal Research Institute was conducted under the guidance of Dr. Y. Mae. The usual assortment of machinery for testing fatigue, impact and tensile strength was seen. There was also a machine to test wear and an Erichsen cup test to assess metal formability. A very extensive collection of corrosion and stress corrosion testing equipment was observed. For example there were numerous autoclaves for testing in high temperature–high pressure water and also loop-test facilities under high-temperature, high-pressure water conditions. Alloys under test are Hastelloy, Inconel, Monel and zircalloy. The specimens are mostly U-bend and smooth-tensile, in addition to the tube and pipe-flow tests.

Wet corrosion tests include the rotating disk type to study velocity effects, jet impingement tests to study erosion of Cu-base alloys (Al-bronzes) in seawater, salt spray tests (for Al alloys), stress corrosion tests (smooth specimens in moist air, ammonia and boiling 52 percent magnesium chloride) wet-dry cycle tests in seawater and

an ultraviolet wet-dry-sunshine test chamber. There is also an ultrasonic cavitation test facility. As a finale to the tour, the Shimadzu SMX-50 X-ray diffraction stress analyser was shown. The machinery was bulky compared to the equipment developed by Cohen and James at Northwestern University under ONR contract.

In technical discussions, Dr. H. Doi, Director of the Powder Metallurgy Division described some work (with Y. Shimaniki and M. Masui) on variations of the composition of the γ' phase in the Ni-base superalloy Udimet 520 with aging temperature. At 800°C there is an arresting of coarsening of the γ' phase at about 50 hours. This is not observed at higher or lower temperatures. Doi explains this as a depletion of Al and Ti in the Cr-rich region around the particles which occurs at 800°C and 50 hours (see Scripta Met *10* 805 (1976)).

Dr. Y. Mae described studies on the effects of temperature and cross rolling on Ti-Al-2.5Sn and Ti-6Al-4V alloys. The experiments involved straight and cross rolling in the beta range followed by either straight or cross rolling in the alpha + beta range. The effects on the tensile properties, hardness anisotropy and texture were examined. The conclusion was that the most uniform properties are obtained by cross rolling in the alpha + beta range, irrespective of the initial working procedure in the beta range.

Dr. Mae has also described a method of preventing edge cracking during the rolling of aluminum alloys, by attaching a more ductile material to the edges of the slab before rolling (Jr. Light Metals *26* No. 6, 1976).

Important papers by Dr. H. Doi and others have appeared in Proceedings of the 1976 Powder Metallurgy Conference, sponsored by the Metal Powder Industries Federation and the American Powder Metallurgy Institute. In one paper the strengthening of cermet binder phase through precipitation of intermetallic compounds is described. The strengthening through ultrafine grain carbide generation is promising for the eventual application of cermets in machining operations now requiring high-speed steels. The fine-grain cermet would resist wear and reduce the tendency of the tool to weld to the metal being machined. In the other paper, hot forging of powder metal products without the usual intermediate sintering step is proposed.

The two most interesting observations made during the visit concerned items which could not be discussed in detail, for understandable reasons. First, there are tests going on of Zn-base and Al-base sacrificial anode materials. Obviously, these developments are intended for a highly competitive market, and the details of composition and structure are under study to enable the company to compete successfully. Secondly, there has been a development of Cr-base alloys which is most attractive. These Cr-base alloys are resistant to both nitric and hydrochloric acids. They can be hot-forged and hot-rolled up to 30 percent. It appears therefore that a new class of alloys has been developed which may be very useful for certain applications, and may have real importance to the U.S. Navy despite problems with chromium availability.

OPERATION CHERRY BLOSSOM TRIP TO JAPAN AND HAWAII

Arnet L. Powell

INTRODUCTION

A trip was undertaken on 5-14 January 1977 to escort three top United States High School Science Fair Winners on a tour of Japan and Hawaii. One of the students was the Navy winner and the others had received corresponding Air Force and Army awards. The tour is known as the Cherry Blossom Award or Operation Cherry Blossom and is sponsored by the United States Army. The U.S. students were invited to the Japanese Science Fair Awards Program in Tokyo to receive additional prizes from the Japanese government. The U.S. Army made the necessary arrangements for the various events in Japan and provided local transportation with staff cars and mini-buses. Visits were paid to the American Embassy, the ONR Tokyo Branch Office, two centers of scientific and technological interest, and several general sightseeing and shopping trips were undertaken. Two additional days were spent in Kyoto to which city the group was transported by a bullet train of the Japanese National Railways. In Hawaii the students and escorts were accorded a brief respite before returning to their homes. In the material that follows the tour will be reported in a chronological manner.

CHERRY BLOSSOM TOUR PRELIMINARIES

The trip began for all of us with the U.S. Army Research Office in Durham, North Carolina, forwarding communications on passport and visa procedures, immunizations, customs, itineraries, airline schedules, and advice on what to pack and take with us. The Army insisted that we receive all inoculations required by the military for the Japan area. Obtaining a Japanese visa was a must. All flight reservations and hotel bookings were made by the Army Research Office by Anne Taylor, the Army Project Officer for Operation Cherry Blossom, who proved to be an invaluable fountainhead of advice and information. All flights were scheduled for 5 January so that we could rendezvous in the Sheraton Hotel at Los Angeles Airport on the evening before embarkation to Japan.

I left Boston on Wednesday, 5 January on a 12 noon American Airlines flight to Los Angeles. The weather in Bostor was fair and cold. What I feared most didn't occur: a major snowstorm that might have caused me to miss the important get-together at Los Angeles Airport. In fact, it almost happened to Carol Levandoski of Science Service who missed her plane at Dulles Airport because of snow in the Washington, D.C. area. However, she was fortunate to catch another flight that landed her in California in the late afternoon of January 5th. As it turned out, all three students and all three escorts made it to Los Angeles Airport in time to meet for dinner that evening and get acquainted before departing for Tokyo on the following afternoon.

The Operation Cherry Blossom group consisted of the following people:

Miss Karen Sue Mikkelson San Diego, California	*Army winner (18 years old)* Scientific interest—Medicine and Health
Robert J. Partyka Columbus, Ohio	*Navy winner (18 years old)* Scientific interest—Engineering and Radiology
John H. Runnels Baton Rouge, Louisiana	*Air Force winner (16 years old)* Scientific interest—Mathematics and Chemistry

Ms. Carol Levandoski Science Service, Inc. Washington, D.C.	*Science Service Representative and escort* Works with the International Science Fair.
Mr. Mutsuya Matsumoto U.S. Army Research and Standardization Group London, England	*Army escort* Formerly with the U.S. Army R&D Group, Tokyo, which closed a year ago.
Dr. Arnet L. Powell Chief Scientist Boston Branch Office Office of Naval Research	*Navy escort/observer* Traveled in Japan on ONR assignments on two other occasions.

TOKYO ACTIVITIES

On the eve of departure from Los Angeles, a belt of thunderstorms moved into the area with accompanying lightning and heavy rains. At least two airplanes were struck by lightning during the evening and one of these, an Air New Zealand aircraft bound for Tahiti, was damaged sufficiently to require its return to the airport. It was still raining the next afternoon when the Operation Cherry Blossom group boarded Pan American Flight Three for Tokyo. We took off half an hour late at 2:30 p.m. on a 10-1/2-hour non-stop flight up the Pacific Coast and over the Aleutian Islands to Japan. About fifteen minutes or so after becoming airborne, while passing through a cloud bank, we experienced a sharp static discharge on the right wing. A few minutes later after visual inspection for possible damage, the pilot announced over the public address system that there appeared to be no damage and he would proceed to Tokyo. This we did, and without further incident arrived at Haneda Airport at 6:15 p.m. on January seventh, having lost twenty-four hours by crossing the International Date Line. The temperature was 47°F. and the weather was clear as we were met by U.S. Army Command cars and a minibus from Camp Zama to take us to the Hotel Sanno in the Akasaka Section of Tokyo. The Sanno, as the U.S. military billeting facility in the area, provided a convenient and relatively inexpensive place for the Operation Cherry Blossom group to stay during its week in Tokyo.

The next day, 8 January, being a Saturday, was utilized for shopping and sightseeing. The weather was very fine, relatively mild and with no snow on the ground. The group was met at the Sanno Hotel by two Army staff cars and we were off first to the Asakusa district to visit the famous shrine and its attendant facilities, as well as to shop at the little stores and bazaars in the area. It was extremely helpful to all of us that Mr. Mutsuya Matsumoto, the U.S. Army escort, and Mrs. Helene Fujita of the U.S. Army Public Affairs Office at Camp Zama were with us to act as interpreters and guides.

The day proved to be very instructive and profitable for students and escorts alike. Many pictures were taken, and as was the case throughout the entire tour, U.S. Army photographers were present to record the various events and happenings. We all enjoyed trying the bean curd cookies and rice crackers which were available at the small stands in Asakusa. Later in the morning we were driven to the World Trade Building, a very modern skyscraper on the 40th floor of which a glass-enclosed concourse provides striking views of the city of Tokyo. After enjoying this experience for a half-hour or so, we repaired to the basement of the building to take lunch in a small Japanese restaurant. It was amusing to watch the young people struggle with chopsticks for the first time but they were game and learned rather rapidly. By the time the week was over they were nearly as proficient as the natives.

In the afternoon we were driven to the Ginza but did not visit any of the big department stores. Instead, we shopped at the Oriental Bazaar which offered a potpourri of choices, a small imports store, and a fabulous Japanese toy shop. I still can see and hear the little teddy bear and his drum on one of the top floors - there must have been a powerful battery inside him somewhere for the beat went on and on.

After a brief return to the Sanno Hotel to deposit a mountain of purchases, Mr. Matsumoto and Mrs. Fujita escorted us to a Tokyo restaurant that featured pork roll in several varieties, boiled rice, and cabbage

salad. It was a very crowded place but somehow the management kept track of the people coming in and maintained proper seating order. Although one found himself rather crowded when he finally reached the little stools at the big U-shaped counter, the food proved to be excellent and reasonably priced. In the evening, the students and Carol Levandoski went to a Japanese discotheque near the Sanno which featured a local combo doing American country music. Since my own teenagers provide me with enough cacophonous noise of similar nature at home, I begged off for the evening to go to bed early and help cure my jet lag.

The highlight of the visit to Japan was the Japan Student Science Awards ceremony and luncheon which was held at noontime on Sunday, 9 January, at the luxurious Keio Plaza Hotel in Tokyo. This affair was a very large one at which the top winners in middle school and high school science fairs from all over Japan were invited to receive recognition for their achievements. The American students were the only foreigners invited to participate and to receive awards. Japanese royalty, in the persons of Prince and Princess Hitachi, were invited to the luncheon and took part in the awards program. Prince Hitachi is the second son of Emperor Hirohito and, like his father, is a marine biologist. The Princess is a very lovely and well educated lady, formerly a commoner we were informed.

At the appointed time, our group was led from a reception room where we had been waiting to the enormous banquet hall filled with tables representing communities from all parts of Japan. Over 500 Japanese students were in attendance, dressed in the traditional dark blue student uniforms. There were some vacant tables occasioned by absences brought about by heavy snowfalls to the north and west of the Tokyo area. The head table was very long and faced the main entrance to the banquet hall where the Prince and Princess were to enter and exit. A symphony orchestra was seated at the right (the Channel 4 TV Orchestra, sponsored by a Tokyo newspaper). The table itself was set in Western style with knives, forks, and spoons. The menu and programs, however, were entirely in Japanese. Each place at the table had a card identifying the occupant and only those before the Americans were in English. In fact, the only Americans seated at the head table were Major Strachan, Chief of Public Affairs, United States Army, Japan; Mrs. Helene Fujita, of his office; and the three escorts. The three United States Science Fair winners were located at a special round table immediately in front of the Americans.

When the time came for the Prince and Princess to join the group, the main doors to the hall were closed briefly. Upon a note from the orchestra, they were reopened and the royal couple entered with their retinue. The Prince was dressed in a dark blue business suit and the Princess wore an elegant green kimono. All present in the room stood and clapped their hands until the Prince and Princess were seated in special chairs at the center of the head table. There were several short, ceremonial speeches before the luncheon was served; as one would expect, the entire affair was conducted in Japanese and English was not spoken at all. After a first course of a seafood cocktail and a second one of soup, and just as the main course was being served, the presentation of awards commenced. Much to our surprise the American students were called first and some of us nearly missed the open-face sandwiches that were being offered just then by the white-gloved waiters. Our representatives comported themselves well, bowing very properly as they passed before the royal couple. Following this, the Japanese students were recognized, school by school, which took a long time during which the final courses of the meal were served, a fruit cup and after that something that resembled a slice of jelly roll. At the very end glasses of orange juice were delivered and, on a signal, we all stood and toasted the winners.

Following these proceedings which had consumed the better part of two hours, we were subjected to a moderately long speech on meteorology and weather patterns in Japan. The talk was followed by the rendition of two pieces by the symphony orchestra: Selections from Johann Strauss and Sibelius' Finlandia. Finally, on a signal from the orchestra, we all stood and clapped hands again as the Prince and Princess rose from their seats, left the table and descended to the main floor to mingle with the students. They first talked with the all-Japan prize winner, a girl who had conducted a study of hibernation of tadpoles, a subject which obviously fascinated Prince Hitachi. The royal couple also conversed in very friendly fashion with each of the U.S. Science Fair awardees, exhibiting interest in their projects and their career aspirations. The students were charmed by this experience and were greatly impressed with the Princess' fluency in English. Shortly after their conversations with the American high school students, the Prince and Princess were escorted from the room and the awards luncheon was over. We returned briefly to the same reception room we were in earlier in order that the U.S. students

might receive congratulations from Japan Science Fair officials. Gifts were also presented to the winners and to all others in the U.S. group.

January 10th was set aside as a day to visit the American Embassy, Camp Zama, and a scientific research institute. At the Embassy, the group first visited the ONR Tokyo Office where we were welcomed by Dr. Morton Bertin, Scientific Director, and Eunice Mohri, his Administrative Assistant. The group then met with Minister Thomas P. Shoesmith, Deputy Chief of Mission in the American Embassy, who discussed with each of the three students his or her scientific interests and future career aspirations. We also met briefly with the NSF and ERDA scientific representatives in Tokyo.

After lunch at the Embassy cafeteria, the group, including Dr. Bertin and Miss Mohri, traveled to Camp Zama in a minibus provided by the U.S. Army. Here we made a courtesy call on Lieutenant General J. R. Guthrie, Commanding General, U.S. Forces, Japan and Okinawa, and visited the Public Affairs Office. We were then driven to the Mitsubishi-Kasei Institute of Life Sciences which is located in a wooded area near Tokyo. This Laboratory was established recently by the Mitsubishi Corporation to conduct a broad program of basic research in the life sciences. Additionally, the results obtained will be utilized by industry and it is hoped that the program will provide a truly effective model for industrial and academic cooperation. The institute was fortunate in being able to engage Dr. Fujio Egami, who retired from the University of Tokyo at just the right time, as Director.

Dr. Egami has organized his overall program to contribute to the advancement of the life sciences through use of the physical sciences, and to promote the welfare of mankind by improvements in medical treatment, environmental preservation and industrial technology. In order to achieve these objectives, he established the following departments: (1) General Life Sciences, aimed mainly at research in biopolymers and cells; (2) Neuroscience, with the objective of studying brain and nerve functions by physical science techniques; (3) Environmental Life Sciences, to protect and preserve the environment; and (4) Special Research, for a variety of selected projects of academic and industrial interest.

Dr. Egami, unfortunately, was not present when the group visited the Mitsubishi-Kasei Institute. Dr. Hiroshi Kawamura, Head, Laboratory of Neurophysiology, and Mr. Katsuhiko Matsumoto, Chief of the Research Coordination Department, greeted the guests and provided a brief general explanation of the mission of the institute and its ongoing research programs. We were then taken on a rather hasty tour of the laboratories and heard some brief explanations of research in progress on thermophilic bacteria, neuroscience, neurophysiology, biochemical reactions, biocatalysis, and preparative organic chemistry and biochemistry.

Leaving in the late afternoon for the Sanno Hotel, we were treated to a first-hand example of the horrors of Tokyo traffic. The freeways into and in the city can indeed become "the longest parking lots in the world."

The eleventh of January was to be the last day in Tokyo before the operation Cherry Blossom group traveled to Kyoto on a bullet train for a two-day visit to that area. At 10:30 a.m. we were picked up by the U.S. Army minibus to be driven to Tokyo Central Railway Station. Before boarding the train, we were to be accorded the rather rare privilege of visiting the General Control Center for Shinkansen, the super express bullet trains. Since Dr. Bertin had not been able to visit this facility, he took advantage of this opportunity and came along with us.

At 11 a.m. the group was ushered into a conference room outside the General Control Center in the Central Railway Station where an official of the Japanese National Railways described briefly the operation of the Centralized Traffic Control (CTC). At present, the Shinkansen extends from Tokyo to Hakata Station in Fukuoka, Kyushu Island, a distance of 1069 km. Two types of super express trains are operated: the "Hikari" and the "Kodama." The latter makes more stops; in both cases the maximum speed attained is 210 km/hr (about 130 miles per hour). To assure safe operation of these trains, an automatic, computerized traffic control system is used. All dispatching and controlling of the bullet trains is carried out at the General Control Center in Tokyo Central Station. In this center there is a long indicating panel on which the entire route of the bullet trains between Tokyo and Hakata is recorded. The train dispatchers constantly watch the operation of each train on the indicating panel. A centralized traffic control panel is located directly in front of the indicating panel which

controls remotely all switches and signals along the route. A variety of safety devices are incorporated to prevent collisions and overruning of trains, to provide waiting periods for the faster trains to pass, and the like, all automatically controlled. Seismographic devices are installed at various points on the route which automatically stop the trains if an earthquake achieves a rating of 3 on the Japan scale (4-5 Richter). Despite the dependence on automation, two motormen are assigned to each train who can assume manual control if required. Communications are established at all times with the trains by radio and wayside telephone. It is possible to communicate freely with the motorman or conductor at any time, and in case of emergency, the necessary instructions can be transmitted at once. The control system has worked very well to date and this swift, modern train service has become a model for worldwide emulation. Recent statistics released by Japanese National Railways show that about 430,000 passengers per day are transported on the bullet trains, the one billion passenger mark was passed last May and the trains are earning 1.3 billion yen a day.

VISIT TO KYOTO

After this pleasant and informative visit to the General Control Center, the Operation Cherry Blossom Group, which now comprised the three students, the three escorts, Mrs. Fujita, and an Army photographer, boarded a Hikari train. This train departed from Tokyo at 12:36 p.m. and arrived at Kyoto about three hours later, having made only a single intermediate stop at Nagoya. The train was clean and comfortable and the ride was relatively smooth. We ate lunch in the dining car and found the food to be tasty and satisfying.

After disembarking at Kyoto City Station, we engaged two taxis to take us to the Rakutoso Inn (Inn of the three Sisters), which is situated near the garden of the Heian Shrine. This hostelry was arranged in the style of a Japanese Inn with tatami mats, sliding shoji doors, and sleeping arrangements on the floor. Shoes had to be removed at the door before entering the inn. Breakfast was served in a special room on the first floor where one sat crosslegged on pillows at a low table. Thus the three U.S. students were provided with the experience of living under more traditional Japanese conditions, which they appeared to enjoy. After unloading our luggage and changing our clothes, we hurried off to dinner at the famous Minokichi restaurant in Kyoto before taking a Japanese night tour of the city.

This night tour was an unusual experience which would not ordinarily be available to Western tourists. Without the presence of Mrs. Fujita and Mr. Matsumoto, we would not have been able to take it. The tour started from a terminal used only by the Japanese; the seats on the bus were too small for Westerners (especially one of my proportions), all other persons in the group were Japanese and the tour guide spoke only in that language.

We went to three different places. The first of these was the Gion Corner Theater where we were escorted to an auditorium at the top of the building which was unheated, freezing cold, and again with seats designed for orientals. A brief show of perhaps 10 minutes duration was staged by one apprentice Geisha (Maiko) who performed a few routines of two different traditional dances. We then left the theater, reboarded the bus and traveled to a very old part of Kyoto where we were informed that we would see the real Geisha perform. After walking through some dark alleys, the visitors were ushered into a small theater which once more had narrow, uncomfortable seats. Here a rather corpulent, middle-aged Geisha, who Mrs. Fujita stated had been declared a "Living National Treasure," performed a brief version of the tea ceremony with the aid of a young Maiko and a volunteer from the audience. After this performance she came down the center aisle to demonstrate how the Geisha must walk with a labored, sweeping motion when wearing the large, high wooden clogs. We were also informed that it takes about six hours for a Geisha to dress, including three hours to do up her hair. John Runnels and Bob Partyka remarked to me that the Geishas were a "ripoff" and certainly not what they expected. I observed that most Americans have an erroneous concept of these entertainers.

Finally, for the last event of the evening, we boarded the bus once more and were driven to a Buddhist temple where we had to remove our shoes before entering the premises. The group was escorted to a large room where, kneeling on tatami mats, we received green tea prepared in another version of the tea ceremony. The liquid in the cups resembled somewhat the green scum seen on stagnant ponds in the summer time and probably didn't taste much better. Eating the traditional sugar cookies before sipping the tea did help to some extent in making the portion more palatable. Meanwhile, a young Buddhist priest, with close cropped hair and wearing

religious garb, gave a long speech on the history of his temple, the tea ceremony, and other related matters in Japanese. Evidently his sense of humor was remarkable, judging by the rather frequent gales of laughter emanating from the Japanese in attendance. Unfortunately, since neither the discourse nor the jokes were understandable to the Americans present, and the interior of the temple was quite cold, we were glad when the evening ended with a brief musical performance. This concert was provided by two traditionally dressed girls on the koto, the ancient Japanese thirteen-stringed instrument which is played in a horizontal position on the floor.

The next day, 12 January, was set aside for sightseeing and shopping in Kyoto for the benefit of the three students. It had been decided earlier to omit Nara from the itinerary because there was so much to see and do in Kyoto. After breakfast at the Inn of the Three Sisters, the Cherry Blossom group boarded a bus for the morning tour of Kyoto. This tour encompassed visits to three important historic and cultural sites: Nijo Castle, the Golden Pavilion Temple, and the Old Imperial Palace. Nijo Castle, which was the shogun's (generalissimo or dictator) residence in the old capital city was impressive with its old-style architecture, lavish rooms and rich paintings. Especially entertaining was the so-called "nightingale floor" which chirps like a flock of birds when walked over and served to warn the shogun of the approach of a possible assassin.

The Golden Pavilion Temple, which was the second stop of the trip, presents a truly beautiful view as the gold-painted three-story structure is mirrored in the pond on which it borders. Originally a pavilion on the estate of a retired Ashikaga shogun, it later became a Zen buddhist temple. The pavilion is an exact replica of the original which was destroyed by a fire in 1955. This is a marvelous spot to take pictures and all of us took advantage of the opportunity.

A visit to the Old Imperial Palace completed the morning itinerary. This extensive group of very old buildings constituted the emperor's residence when Kyoto was the capital of Japan. It is used very little today except for a few state occasions such as a coronation. The garden and the grounds are very attractive and it is another excellent site for photography.

The afternoon of this day was spent entirely in shopping. The Kyoto Handicrafts Center, which was situated near our inn, was patronized heavily. Later the group went into the center of the city to visit additional shops.

On the evening of this date, I took the opportunity to have dinner with my old friend Dr. Atsuyoshi Ohno and his family. I first met the Ohnos when I came to Japan in 1962 and became reacquainted with them in the middle sixties when Dr. Ohno came to Cambridge, Massachusetts, and undertook two years of postdoctoral work at M.I.T. Dr. Ohno was instrumental in organizing the tour of Japan that I made in the late summer of 1972 for ONR. He is presently serving as Associate Professor of Chemistry at Kyoto University.

On the final morning in Kyoto, 13 January, we breakfasted early and rushed off to visit two famous temples before returning to Tokyo on the 11:05 a.m. bullet train. The first of these was Nanzen-ji and is one of the best known Rinzai Zen temples in Japan. It has a famous stone garden which is sometimes called the "Leaping Tiger Garden" because of the shape of one of the rocks. The second temple we visited is known as Kiyomizu and it enjoys a strikingly scenic setting on the top of a high hill. The temple has many uniquely beautiful buildings and is famous for its pure spring water that one may drink from long-handled dippers which act is supposed to ensure a long and happy life. As we came down from Kiyomizu to return to the Inn it began to snow. The snow continued as we bundled into taxis to go to Kyoto City Railway Station and became rather heavy before we arrived there. However, the train rapidly left the stormy sector and the return to Tokyo took place mainly in fair weather.

After a few hours at the Sanno Hotel for final shopping forays and to pack our bags, the Army cars took us to Haneda Airport for a 9:30 p.m. departure for Hawaii. Major Strachan, Mrs. Fujita, Mr. Matsumoto, and a U.S. Army photographer accompanied us. It was here we said goodbye to our friends from the Army and Sayonara to Japan as we inched our way through the very long security line to our Northwest Orient Flight to Honolulu.

HAWAII FINALE

The night flight to Hawaii was smooth and uneventful except that the water system on the plane was not functioning. The flight crew's response to this problem was to provide cans of soda in the lavoratories for washing. A not unpleasant deodorant when mixed with soap! After arrival in Honolulu in the morning (still 13 January, thanks to the International Date line), we managed to get by a rather testy customs inspector, albeit without any real problems, and taxied to our hotel.

The stop in Hawaii provided an opportunity for the students and escorts to recuperate from the rather hectic Japan tour. The group was billeted in a Waikiki hotel where they were able to enjoy the beach and other local attractions. On the morning of 14 January, the students were taken on a tour of Pearl Harbor, which included a visit to the Arizona Memorial. Later in the day the group drove around the island of Oahu in a car provided by Science Service. At 8 p.m. on that evening, we said our final alohas as the three students and Carol Levandoski departed for Honolulu International Airport enroute to their various homes. I stayed on a few days to see what I could do to persuade the Navy at Pearl Harbor to arrange Science Cruiser Awards in Hawaii for Continental U.S. Science Fair winners, commencing in the spring or summer of 1977. I made this contact on 17 January, and in the light of subsequent events, it appears that I was successful and that Science Cruiser Awards will indeed begin this year.

INDIAN INSTITUTES OF TECHNOLOGY
DELHI, KANPUR, MADRAS

Leslie S. G. Kovasznay

After independence there was a movement in India to strengthen education in engineering and related fields by setting up by a number of institutions. Help from industrially more advanced countries was sought and obtained. Finally a total of five Indian Institutes of Technology (IIT) were created, each assisted by a different country or international organization. IIT, Delhi received assistance from Britain, IIT, Kanpur from the United States, IIT, Bombay from the USSR and IIT, Kharagpur from UNESCO. The foreign help included both capital equipment and visiting faculty in the first few years; the buildings were constructed from Indian funds and the permanent faculty is, of course, Indian. I was able to visit three of the five IIT's, namely, those in Delhi, Kanpur and Madras. Since the period of intense involvement by the assisting foreign countries is essentially over, it is interesting to observe how lasting is the influence of the different foreign sponsors.

First, IIT, Delhi was visited. It was established in 1961 as an autonomous statutory organization. The Indian government accorded it with powers to form its own degrees. Collaboration with the United Kingdom is operative primarily through the Imperial College in London and in addition some other British universities are also involved. There is a standing committee, the Imperial College Delhi Committee in London. It acts as a group of consultants to the British Government and also it provides for an academic interaction between I.C. London and IIT, Delhi. Recently the committee was enlarged to include representatives of the University of Birmingham, Leeds Loughborough, Manchester, Southampton in order to provide a wider basis for academic collaboration. Quite recently, IIT, Delhi established collaboration with a European institution outside of Britain, namely with ETH, the Swiss Federal Institute of Technology, Zurich, but this is only in one field (Biochemical Engineering).

The total enrollment of IIT, Delhi is about 2,000 students, a little more than one half of them undergraduates and among the graduate students about 470 are enrolled in programs leading to the Ph.D. The campus is located outside of Delhi proper in South Delhi about 15-20 km from the central portion of the capital. Like many similar institutions in India it is a "residential institution" meaning that there is sufficient dormitory space provided to house all students. Also there are faculty residences for most of the faculty members as well for at least some of the supporting staff. In view of the relatively low salary levels in India, housing is a very important component of the staff remuneration. Dormitories are rather essential for most students as they could not live economically on their own and commuting from the city of Delhi is not very practical either. The Institute provides a self contained community for both faculty and students with recreational facilities, etc. The campus is spacious and handsome.

IIT, Delhi being a technologically oriented institution, has some innovative features that emphasize the role of science and technology must play in a developing country like India. There are interdisciplinary schools such as the School of Energy Studies, School of Material Science and Technology, School of Systems and Management. In addition there are a number of research projects in areas such as Solid State Devices and Integrated Circuits, Laser Application and Technology, Food Processing and Preservation, Ecology, Maintenance Engineering, and Tribology. In spite of these new interdisciplinary schools, the traditional departmental structure is also maintained. Recently an Industrial Consultancy and Liaison Centre (I.C.L.C.) was established in order to undertake comprehensive development projects both for government and industry.

In the Department of Applied Mechanics, Professor R. C. Malhotra is directing a pilot plant study for the hydraulic transportation of bauxite ore. The study of the rheological properties of the bauxite ore slurry plays a central role to these technologies. The project was motivated by the interest in a possible method to transport bauxite ore for a distance of 73 km from the mountainous mine area to the west coast of India for further processing it into alumina. A systematic study in a 5 cm diameter and 60 m long pipe loop provides enough of the data on the relevant fluid mechanical properties in order to decide whether or not such a transport would be both technically and economically feasible. In addition of this rather applied project, there is basic fluid mechanical research under the direction of Professor Molhotra. Swirling flows in ducts are being explored by Drs. D. S. Kumar and K. L. Kumar and in connection with this project progress was made in three component velocity measurements by the hot wire anemometer developed by K. L. Kumar and A. K. Raghava. During my visit to IIT, Delhi, Dr. K. K. Chaudhary was my guide and through him I also learned about some interesting developments in Biomedical Engineering. (Professor T. K. Ghose is in charge.) The project was successful in developing a miniature pressure transducer for the direct measurement of cerebro-spinal fluid pressure. Because of the small size and proper choice of the materials, long time implantation appears feasible. Another interesting biomedical project is the development of a transducer to measure the oviductal diameter. Again the aim is to permit long term implantation of a device that is small and nonocclusive. India has a population problem so "F.P." (Family Planning) has a prominent role in the thinking of many scientists, consequently research aimed at some aspect of the human reproductory system as well as instrumentation to any such research effort is quite popular. When reading the list of Ph.D. theses in Applied Mechanics, I was intrigued by the title Abdul Mateen Ahmed "*Reversible Occlusion of the vas deferens.*" I was unable to secure a copy but I understand that a small device was actually implanted in sheep and the whole project was financed by WHO (World Health Organization).

Here it may be appropriate to make one brief comment on Indian names. As some common names keep repeating such as: Murthy, Kumar, Rao, Gupta, Singh, Jain, etc., the correct initials (usually they have two) are *paramount for positive identification* of someone. In South India where the local languages are of a quite different origin (Dravidian languages instead of the Sanscrit based ones of the North) the confusion is further compounded by the custom to have only one name (a given name) that is completely different from the father's. These people, when going abroad, often adopt extra initials and finally they end up using their original given name like a family name in the United States.

When visiting different laboratories of fluid mechanics, one notices that the usual quest for "socially relevant" projects is quite evident and it results in some kind of wind power project at just about every institution I have visited. Of course energy is a major problem in rural India and their effort is quite justified. In rural households the principal fuel for cooking is cow dung dried and stored for future use. In the rainy season the price increases as collecting and drying becomes nearly impossible. Wood is prohibitively expensive. During my visit in Delhi 100 kg (220 lb) firewood cost $4.00. Wind power for rural electricity on a modest scale, at least for pumping water, is foremost in everyone's mind. Coupled with the relatively high expense for metal parts and especially for machined parts, the practical aim is to build windmills that can be locally produced in the village with no "city bought" parts outside the main shaft and two bearings. The preferred choice, at least by the experimenters I have met, is vertical shaft windmills, because these are simpler (no gear box is needed). They are used sometimes in a combination with another set of blades in order to produce higher starting torque at low wind speeds (I have seen canvas sail type of blades at I.I.Sc. Bangalore aimed at making a good starting torque).

It should be mentioned that IIT, Delhi still maintains close ties with the U.K. and each year there are about 15 academic visitors from the U. K. spending a few weeks at IIT, Delhi. In addition about 10-12 junior faculty members (mostly assistant professors) are being sent to the U.K., typically for a six month stay of training and research.

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

The campus of IIT, Kanpur is located far outside of the city of Kanpur and it is a completely self-contained community. Kampur is a developing industrial city that includes a plant of Hindustan Aircraft Co. as well as other manufacturing plants, but the main economic basis of the area is textile and leather industries.

Due to the presence of an aircraft industry in the area, the Aeronautical Engineering Department is quite strong and in the department there are several fluid mechanics projects including some active research on turbulence. In addition to those the Chemical Engineering Department also has a project on turbulence. Professor R. N. Sharma studies the development of a wall jet on a conical surface. This represents a more general case than either the two-dimensional wall jet or the radial axisymmetric plane wall jet, that may be regarded as two limiting cases of the conical wall jet. As it was explained to me, the purpose is to measure in detail a well documented case that can serve as a test case for different turbulent flow calculating methods. They first tried a "two-equation model" of turbulent flow calculation where closure is achieved by solving two extra differential equations in addition to the equation for mass and mean momentum. It appears that their model correctly predicts the wall jet for all cone angles without readjustment of the numerical constants.

My visit to Kanpur coincided with the last day of a special program at the ITT. The Department of Aeronautical Engineering in cooperation with some others has sponsored a special course, "Turbulence in Fluid Flow," that lasted nearly three weeks. Eleven faculty members from IIT, Kanpur actively participated and three visiting faculties (R. C. Malhotra from IIT, Delhi, R. Narasimha from I.I.Sc. Bangalore and R. S. Yajnik from N.A.L. Bangalore) were the special attraction. By a fortunate accident of scheduling, I gave a lecture that was included in the program. When I saw a list of such programs I was especially surprised by the abundance of special courses and seminars in India. In spite of the modest resources of the country, a major effort is made to organize a number of short courses and seminars throughout the year. This offers an excellent opportunity for continuting education for college teachers, especially those who at their own institution have no real opportunity for personal research. The turbulence course at Kanpur was attended by 30 participants.

In the early years of IIT, Kanpur there was a large number of visiting faculty members from the U.S.A. who have spent one or two years there and have contributed to the growth of the Institute. It should be mentioned here that in the late 60's, Dr. T. Vrebalovich, the present Counselor for Science and Technology of the U. S. Embassy in New Delhi, spent two years at IIT, Kanpur as a visiting professor. The fact that he has personally participated in building up that institution is much appreciated everywhere in India and he has many friends dating from that period who are giving him much more help in his present position then they would to someone else who comes in just "cold."

IIT, MADRAS

Madras is a fascinating city. Its history goes back to 300 years and it was one of the first Portuguese settlements. It is located in the southern part of India on the east coast on the Bay of Bengal and it is also the capital of Tamil Nadu State. The Institute is located outside the city in the south in a beautiful 600 acre park where the deer and the other animals roam; they even venture onto the campus. IIT, Madras was built with substantial assistance from the German Federal Republic and it is the largest educational project abroad financed by West Germany. When looking at all three IIT's, it is quite clear that they have different flavors somewhat resembling the sponsoring countries. In Madras I was quite impressed with the neat layout of the laboratories using module units of laboratory space. West Germany contributed in the order of 10 million dollars worth of equipment, instruments, books, and the modern computer, etc. A large number of German specialists have served in Madras (e.g., 46 in the year 1969). Now that the Institute is operating in a more or less steady state, the number of German specialists has tapered off. Many cooperative ventures did develop and many of the Indian faculty members are going to Germany on extensive visits under this continuing cooperation, but now not on an institutional but rather on an individual basis.

The faculty is about 320 members strong and there are close to 2700 students, including some 500 graduate students. Last year, 75 Ph.D. degrees were awarded. In Madras (just as I mentioned it in connection with IIT, Kanpur) there is an organized effort to assist engineering colleges whose faculty takes short advanced courses. In addition there was instituted a new program called "reinvitation program" to maintain a continuing interest and to launch cooperative R&D projects with those colleagues from lesser institutions.

In India all institutions of higher learning wish to participate in a program aimed at improving life in the rural areas. (80% of India's population live in the rural areas and 50% of them are below the poverty line.) To this purpose IIT, Madras set up a Centre for Rural Development and has "adopted" the village of Narayanapuram. In that village, the State of Tamil Nadu has allocated a 94 acre plot to the Institute and the Rural Technological Complex is being set up consisting of several industrial units which are agriculture based and are of the small village type. I was told that the students begin to "win the hearts" of the villagers and they expect to serve as an ongoing catalyst for social transformation and economic progress in the selected village.

The head of the IIT, Madras is the Director, Dr. K. A. V. Pandalai, who received me cordially and explained the general orientation of the Institute. He is a close friend of Nicholas Hoff from whom he received his Ph.D. at Brooklyn Polytechnic Institute in solid mechanics and whom he visited later at Stanford. This is mentioned to show that the West Germany influence is not exclusive. My host on the campus was Professor N.V.C. Swamy of the Applied Mechanics Department. He also serves in the Administration in charge of Academic Courses and Programs (as a kind of a dean). He showed me the research activities in fluid mechanics. Studies on the structure of three dimensional turbulent boundary layers are being carried out both experimentally and by a computational method. There is a continuing systematic study of the performance of both two dimensional and axisymmetric diffusors and nozzles. Turbulent wall jet is another subject of research. The formation of a liquid film from swirling spray devices is studied experimentally. Briefly, I visited also the rotating machinery laboratory and the combustion research laboratory. Both appeared to show the "German approach" which is quite understandable as there was a large transfusion of the "Technische Hochschule" spirit, with the high quality machinery hall and also with the "no-nonsense" applied engineering orientation.

Looking back at all three IIT's I could conclude that India was fortunate to have been exposed to different approaches offered by different countries' scientific and engineering communities and this variety is bound to enrich the whole technical education. The real problem now is rather the strong unemployment problem of university graduates which makes for a very gloomy outlook for most students in India.

"ACOUSTIC RADAR" AT THE NATIONAL PHYSICAL LABORATORY OF INDIA

Leslie S. G. Kovasznay

The Council of Scientific and Industrial Research (CSIR) of India comprises a large number of research organizations. In fact CSIR is a kind of umbrella organization designed to administer government support to formerly independent research laboratories. After having met with the Director General, Dr. Y. Nayudamma, I was taken to the NPL (National Physical Laboratory) where the Director, Dr. A. R. Verma, had arranged my visit to inspect some special projects of interest. Instead of providing here an overall survey of NPL's activities, I wish to single out one project I found rather interesting. The project leader, Dr. S. P. Singal, has developed an "acoustical radar" and he has coined the word "SODAR" (sound radar) to designate it. It consists of a strongly directional acoustic transmitter-receiver system. In a typical operation the transmitter signal is a pulsed sound power with the following characteristics: the carrier frequency is 1000 Hz, the pulse width 60 msec and the pulse repetition rate is 2 pulses per second. The back scattered acoustic waves are received and then recorded and analyzed. In most applications the beam is directly vertically upward and the back scattered signal is received. The "SODAR" primarily responds to the temperature inhomogeneities in the atmosphere within the first few hundred meters. One advantage of the system is that continuous monitoring is inexpensive and it can reveal many interesting features in the lower atmosphere. Those may be either of short-time scale or of long-time scale phenomena. Typical features that can be successfully observed are: thermal plumes in the lower atmosphere, stable inversion layers and the gravity waves that travel along those inversion layers. Horizontal spatial variations are observed at a temporal record due to the omnipresent average wind velocity that permits the conversion of a temporal record taken at location into a spacewise record along the horizontal coordinate in the main wind direction (by assuming a nearly "frozen" pattern). The distinct advantage of the "SODAR" method is that it also operates without difficulty in clear air turbulence as it does not depend on the water vapor content but rather, as stated earlier, on temperature variations. The transmitters are typically horn-type "antennas" but paraboloid reflectors fed by a small horn were also used. The typical beam half width is 7°. As in all monostatic pulsed systems the essential component is the T-R switch that turns off the signal to the receiver during the transmitter pulse in order to avoid overloading of the sensitive receiver system. Since India now has a satellite orbiting overhead, plans are being made to integrate the information obtained from the weather satellite with that of the "SODAR" located at a fixed geographic point.

MHD POWER GENERATOR PILOT PLANT IN TIRUCHIRAPALLI

Leslie S. G. Kovasznay

Energy is a problem for almost every country, but for India it is an especially crucial one. I consulted a recent report written by Dr. K. L. Kumar, IIT Delhi, to illuminate the point. He gives the per capita power generating capacity installed in different countries, which varies as shown below:

USA	1.80 kw/person
USSR or Japan	0.7 kw/person
India	0.03 kw/person

Furthermore, in India the sources of energy are also quite different from the U. S. or Europe. In the table below a comparison is given between the distribution in 1950 with the hopeful projection for 1980:

source	coal	oil	wood	organic waste	cowdung	hydro-electrical	total
1950 % (actual)	16	10	48	14	10	2	100
1980 % (projected)	22	33	23	7	5	10	100

In rural areas the dried cowdung is still the chief household fuel (the only consolation is that it is a renewable resource), but when I had a chance to discuss this problem with Dr. Satish Dhawan, Director of the Indian Institute of Science, Bangalore, I asked him whether it would not be more efficient to use the cow manure as fertilizer instead of burning it. He pointed out to me that great progress could be made by generating CH_4 (methane) gas from cowdung by a well-known and simple process, then use the gas as a household fuel and the remaining solid would still make excellent fertilizer rich in nitrogen. The chief obstacle of such projects is education at the village level, the development of the grass roots of a rural technology. The ground rules for any such project are that one must produce almost all components locally and use only a minimum of parts that need to be "imported" from the cities.

Nuclear energy is of course very much on the minds of the Indian technocrats. Upon the invitation of Dr. R. Ramanna, Director, I briefly visited BARC (Bhabha Atomic Research Centre) in Trombay, a suburb of Bombay. Not being an expert on nuclear matters, I was given the typical V.I.P. tour of the facilities, showing me with pride how they can successfully produce many medical and biological radioactive isotope products and even export them competitively. The reason for India's competitive position was pointed out to me by Dr. Rao, the Director of Engineering Services. He explained that many of these biological products (mostly radioactive isotope labeled organic compounds) are quite labor intensive, therefore they are competitive in the export market. BARC is really a large modern establishment with about 10,000 employees and of those there are about 4,500 university graduates. The Center also operates an educational program in nuclear engineering. Each year they take in about 200 young engineers (typically with a B.S. degree) for an intensive course of one year duration. There are about 6,000 applicants each year for the 200 places. Usually the admission committee at BARC succeeds in weeding out about 5000 of them by correspondence simply by looking at the candidates' credentials,

transcripts, etc., but the remaining 1000 are all personally interviewed (their travel expenses are paid by BARC). On this basis the final 200 are selected. What makes the program so popular is the virtually assured employment of the graduates in attractive posts. When I planned my visit to BARC, I was especially interested in their project to build a pilot model MHD power generator in South India at Tiruchirapalli. This project started about one year ago as a cooperative venture between BARC and BHEL (Bharat Heavy Electricals, Ltd.) and in addition some Soviet assistance was offered. According to Dr. Ramanna, they were able to obtain information on the Soviet experience with a MHD pilot plant power generator near Moscow. The Soviet plan to use MHD generators for peak power demand and they are quite interested in this somewhat different approach carried on in India. I discussed the problem further with Dr. Shri C. Ambasankaran, Director of the Electrical and Instrumentation group at BARC who was absent during my visit there, but fortunately he attended my lecture later at NAL in Bangalore. He explained to me that several agencies and also some companies are interested in the possibly high efficiency of power generation by direct conversion that is near 50%, especially if the hot exhaust gases from the MHD generator are used further to heat conventional steam turbines. They studied the MHD generator built in the USSR for natural gas as fuel, but in India they expect to use gasified coal. BHEL (Bharat Heavy Electricals Limited) will develop the coal gasification. The Tiruchirapalli pilot plant under construction is a modest one as the emphasis is on the study of technology rather than the practical goal of connecting it into the Indian electrical power grid. In the pilot plant they expect to reach five megawatt peak power by this method. The projected main characteristics are given below. Dimensions of the MHD channel are 10 cm x 20 cm, the operating stagnation pressure is 6 ata, Mach number of the flow $M \approx 1.2$ Magnetic flux 2 Tesla. The electrodes will be water-cooled copper (later they are considering possibly zirconium electrodes too). The insulations are made of alumina. In order to achieve sufficient electrical conductivity the gas will be seeded with barium carbonate. Dr. Ambasankaran reiterated that they understand that in the USSR experience the MHD generators are planned to be used as peak power standby facilities. The most novel aspect of the Indian experiment will be the difference in fuel. Naturally, the technological interest in MHD power generation also created a renewed interest in MHD as a subject even among the academically oriented scientists at the major research centers, e.g., at Bangalore.

ISRO-INDIAN SPACE RESEARCH ORGANIZATION

Leslie S. G. Kovasznay

Space research activities are centered in South India. With the launching of Aryabhata, the first Indian satellite on April 1975, Indian joined the "space club." This is of course a source of great pride and satisfaction at home and some added prestige was gained among the third world countries. After one year in orbit Aryabhata still has some of its systems functioning. Aryabhata was launched with Soviet boosters (Soviet "Interkosmos" rocket) from the Soviet "cosmodrome." It weighs 358 kg and it was injected into a nearly circular orbit with an inclination of 51° to the equatorial plane at about 600 km altitude. The Soviet contribution to the project in addition to launching was limited to a few items such as solar panels, batteries, spin system and the on-board tape recorder. They also performed some early tracking from a station near Moscow (Bear Lake). The scientific package aboard was designed and fabricated in India, and once in orbit there were several experiments carried out.

X-ray astronomy: The operative range is 2.5 – 150 keV. High variability of X-ray emission from Cyg X-1 was observed and speculations were made about the possibility of Cyg X-1 being a potential candidate for a "black hole."

Solar neutron and gamma ray emission: Based on the measurements they are able to estimate an upper limit of the fluxes and also some of their variation with geographic latitude.

Within ISRO the largest group in space activities is the VSSC (Vikram Sarabhai Space Center) near Trivandrum in Kerala state located near the southern tip of India. In fact the city of Trivandrum is the capital of Kerala state. The vicinity of Trivandrum is a truly tropical area and the principal crop is coconut. This was quite evident as during the landing approach one sees nothing but coconut palms for miles and miles. At VSSC there are nearly 4500 employees and about one half are university graduates. VSSC is primarily an engineering center and the only rocket launching facility there is suitable only for small meteorological sounding rockets. On the other hand within the area is TERL (Thumba Equatorial Rocket Launching Station) which was publicly announced to be a facility open to any nation who wishes to launch sounding rockets right along the magnetic equator. TERL is located at geographical latitude 8°32′34″ North, but essentially on the magnetic equator (more exactly 0°24′ South) which permits the convenient study of the equatorial electrojet phenomenon that passes exactly overhead. Another obvious reason for having placed such an important center in the southern portion of Kerala state is the availability of a large number of university graduates from the region for whom this provides a good employment opportunity. At VSSC I was received by Dr. C.L.A. Rao, Director of Aeronautics, and Dr. N. Ventakaraman, Head of Aerodynamics. I was somewhat surprised to learn that there are important aerodynamic facilities (wind tunnels and shock tubes) and a relatively large number of competent scientists and engineers (many of them are U. S. or U. K. trained). Since VSSC was created as a center for an applied engineering activity the more basic research oriented staff members have understandably difficult times in convincing the management to permit them to pursue the basic research of their first preference. This is of course a phenomenon found everywhere in the world.

When in Bangalore I also visited briefly the ISRO Satellite Center and was shown around there by Dr. K. K. Kosta. He described the division of labor among the different groups and facilities within the ISRO family. In addition to VSSC in Trivandum, a new launching facility is being constructed near Madras on the Bay of Bengal. It is named SHAR (Sri Harikota Range) and the first satellite to be launched from Indian soil may be ready in 1978 or 1979. In addition there is ISAC (Indian Space Application Center) in Ahmedabad north of Hydebarad. I can only speculate that there must have been political pressure from the different regions to distribute the

expensive government activities geographically, a phenomenon only too well known in the larger countries around the world. Naturally, much of the actual fabrication of the space craft was contracted out to a number of companies, but the "center of gravity" of all space activities in India is still definitely in the South. The next satellite they expect to launch will be a SEO (Satellite of Earth Observation) with a payload of about 435 kg. It will be equipped with two TV cameras in the IR range (0.55-0.65 micron and 0.75-0.85 micron wavelength). In addition there will be microwave radiometers in two frequency bands (19 and 22 kMc). The whole project is expected to cost about $40 million (U. S.) per year.

At each facility I have visited the staff was very cheerful and quite enthusiastic. They were happy to continue discussions with me beyond their working hours. My only complaint was that I didn't have more time to spend with them.

THE INTERNATIONAL CONFERENCE ON FRACTURE MECHANICS, HONG KONG

Elliot A. Kearsley

On the front page of the South China Morning Post of March 23rd was a detailed photograph of a cracked concrete beam in conjunction with the story of the closure of a local industrial building. The International Conference on Fracture Mechanics was then in its second day and it is not inconceivable to me that the local committee had arranged the story, so thorough were their preparations. How they also arranged for me to crack a tooth on some Chinese dried beef, I do not know, but that was really going too far.

The conference took place from March 21 to March 25 at the Conference Center overlooking Causeway Bay in Hong Kong. It had been organized by George Sih of Lehigh University and C. L. Chow of the University of Hong Kong, who were co-chairmen. The venue of the meeting was chosen both to promote Asian activities and interests in fracture mechanics and to encourage personal interactions, visits and international interchanges from the Western World. It was pointed out at the opening session that the last such conference in Asia had taken place in Sendai twelve years ago. Since then, the Asian needs in fracture mechanics have grown immeasurably. Asia has virtually no sources of fossil fuels and nuclear energy is bound to play a very large role. The nuclear industry is a frequent user of fracture mechanics (perhaps not frequent enough), and heavy industry, which is being developed massively in Asia, is another. As a consequence, research in fracture mechanics is a mainstream of the mechanical engineering activities at the University of Hong Kong and the members of that department were prominent both in the technical program and among the conference officers. The participants at the conference were indeed international. The largest delegation, about 35, was from Japan. A close second was the United States delegation with about 30 members followed by a dozen Australians and an equal number from Hong Kong itself. Other countries represented by only a few attendees were Taiwan, Korea, India, Iran, Israel, Holland, France, England, Sweden, Italy and Canada for a grand total of well over 100. On the planned program were several speakers from Singapore, Czechoslovakia, Russia and the Phillipines who were cancelled at the last minute or did not show for one reason or another. Larger delegations from India, Korea and from Taiwan also had been expected. Representation from industrial laboratories was particularly good at this meeting ($\sim$ 20 people) and a serious attempt was made to couple the scientific progress to practical problems. Considering the current shortage of travel funds at most institutions and the fact that the time of the meeting did not coincide with university vacations (in the Northern hemisphere at least) the attendance was extremely good.

It is customary to trace the origin of fracture mechanics back to an idea of A. A. Griffith formulated in the 1920's, according to which the fracture of a brittle material is a result of the growth of inherent minute cracks or flaws. In this picture, a stressed material becomes unstable when the amount of elastic energy released on extending the largest of the inherent cracks exceeds the surface energy dissipated in increasingly the crack surface. Since the time of Griffith's original suggestion, a series of technological problems of broad public interest have served to stimulate interest in the field. During World War II a series of ship breakages from hastily constructed vessels occurred and subsequently considerable work was done (particularly at the Naval Research Laboratory) to extend the idea for application to metals. The Charpy test was used to delineate the conditions for brittle and ductile fracture and Griffith's ideas were modified to accommodate the behavior of metals. The concept of a critical stress intensity at the crack tip was introduced as a criterion for crack growth. Then, in the 1950's the conspicuous failure of the early deHavilland "Comet," one of the first of the commercial jet aircraft, stimulated the study of fatigue fracture, particularly in the aircraft industry. In the 1960's the high strength-to-weight requirements of ever larger rocket reaction chambers served to reinforce the interest in fracture mechanics. Currently the demands of nuclear reactor design are the most visible spur to research in this field. As a

result of the past successes of fracture mechanics, the present demands are pressing and according to one distinguished conferee "unrealistic considering the current state of the art." Certainly the papers presented revealed many open questions awaiting further study.

Griffith's idea was based on a simple two-dimensional analysis using the linear theory of elasticity to calculate the stress field around an elliptical crack. Of course, innumerable extensions and modifications have been appended in the forty-odd years since. Early on it was realized that energy dissipations other than surface energy must be taken into account—it is the inclusion of plastic deformation losses which makes the theory applicable to ductile fracture. "Classical" fracture mechanics is based on three simple solved problems for the stress field of a thin edge-crack in a semi-infinite linear-elastic solid. These are plane-strain solutions (antiplane strain for Mode III). Mode I is for a tension across the plane of the crack tending to open it up. Mode II is for a shear stress across the plane of the crack tending to slide the surfaces of the crack so as to produce a step in the edge plane of the medium. Mode III is for a shear stress parallel to the line of the cracktip tending to slide the surfaces of the crack parallel to the line of the crack tip without disturbing the edge plane. Of course, these solved problems fail to describe real situations for a number of reasons. Many papers at this meeting dealt with calculating stress fields around models of cracks more reasonable than these, taking into account three dimensional crack shapes or more realistic geometry or "mixed mode" problems where the external forces produce a stress field intermediate between the classical modes. Other papers demonstrated the importance of kinetic energy in salient circumstances or considered the energetics of a crack propagating at angle to its axis (rather than along the axis as Griffith assumed). Nucleation of cracks and coalescence of cracks may play a role in some materials and the stress field of interacting cracks is of interest. And for specific materials, the details of morphology, grain size, crystallite orientation and such is often important. The conference had sessions covering most of these detailed considerations.

Simultaneous technical sessions were conducted (three at a time) consisting of series of related half-hour papers. The topics explicitly covered were fatigue fracture, dynamic fracture, mathematical analysis, dynamic crack propagation, material testing, stress analysis, fatigue crack growth, composite materials, finite element calculations, environmental effects, plasticity, modeling, photoelasticity, bioengineering structures, dynamic testing, strength analysis mixed mode fracture, crack-opening displacement and fracture control, creep, microstructure, nondestructive testing and nonmetals. The following account of some of the papers I happened to audit should give a fairly representative feel for the flavor and content of the conference.

A novel geometry for studying fracture toughness under mixed mode conditions was presented by S. C. Kim of Inha University, Korea. Disks of material with a central internal crack in the form of a slit through the thickness of the disk were placed on edge between the compressional platens of a testing machine. By controlling the angle of the central crack varying degrees of mixing of modes I and II could be produced. Specimens of epoxy and acrylic plastic, cement, bearing steel and marble were used. The direction and pattern of the cracking produced was almost independent of the material used. What then was the best criterion for fracture? Well, that varied according to the angle and hence according to the ratio of modes. Critical stress worked pretty well for small angles between crack and compression but not so well at larger angles.

H. Nishitani of Kyushu University looked at the interaction effects between notches and cracks. This was a calculation using two-dimensional classical elasticity theory and a "body force" method of integrating distributions of Green's functions. A variety of problems were treated: a row of elliptical holes, a row of semi-elliptical edge cracks, a semi-elliptical notch with a small semi-elliptical edge crack on its perimeter, etc.

Analytical solutions for three dimensional problems were presented in two papers by Kawai et al of the University of Tokyo. A wedge-shaped crack in a semi-infinite material was solved in one paper, and a conical pit was solved in the other. Associated Legendre functions were employed and the solutions were in the form of series. In one of the problems the eigenvalues of a 66 x 66 matrix were calculated on a computer! The results were applied to a discussion of stress intensity at the cusps.

Several papers I audited were on the use of finite element methods for the calculation of stress fields. Ando and Yagawa of the University of Tokyo surveyed recent developments in Japan and compared results

calculated by seven different finite element treatments of the problem of a semi-circular surface crack. The stress fields of the different methods did not really vary much except at the surface edges of the crack where one does not expect the stress field to have much effect on the fracture properties. The point can still stimulate a lively controversy among the cognescenti.

C. L. Chow of Hong Kong University presented a paper on the prediction of fracture instability by finite element methods. He pointed out that in the past these methods have been mostly used to calculate stress intensity factors from experimental data, but that to predict instability through finite element calculations of stress intensity required extremely fine grids and massive calculations. He therefore used an energetic approach rather than a stress intensity factor approach since the energy at the crack tip is finite and one can expect a coarser grid to give accurate results. Experimental data taken with PMMA was used for comparison.

P. Tong of the Transportation Systems Center, Cambridge, Massachusetts, gave a talk in which a hybrid finite-element technique was applied to some practical problems of railroad design. In his scheme, polynomial solutions of a finite-element scheme are matched to a singularity at the crack tip. The watchwords were practicality and ease of approximating complex shapes (railroad rail cross sections, a loaded "D" shaped lug with a radial crack, the bolt hole in a rail web, and such). Contact pressure under a locomotive is so high that there is always plastic yielding involved in loaded rail problems. Typical failed rails show horizontal or vertical split heads or transverse fissures. Several Japanese auditors had also worked on railroad problems and were very interested, although they pointed out that the bolt hole problem does not arise in Japan where welded rail is now exclusively in use. (I must admit that the resulting train rides are considerably smoother than those I am used to.)

E. P. Chen of the University of Hong Kong solved the problem of a penny-shaped crack perpendicular to the axis of a cylinder twisted within a reinforcing cylinder of a different modulus. The problem was converted into a Fredholm equation by a transformation and the principal calculational difficulty was in the inversion of the solution. It is a pleasure to see such classical methods still solving new and worthwhile problems.

A good number of papers dealt with the kinetic energy or dynamic effects in fracture mechanics. A paper on branching mechanisms in fracture mechanics by J. D. Achenbach of Northwestern University was particularly interesting. This work is for homogeneous, isotropic, linearly-elastic media in two dimensions—but the dynamic effects are also included and shown to be of utmost importance. Now an earlier work by Achenbach and Bazant had introduced a dynamic correction factor for the stress field at a crack tip. This factor was a function of angle and of crack propagation velocity and has the interesting property that its maximum "bifurcates" out of the plane of crack propagation for large values of crack propagation velocity. Unfortunately, the experimental branching of cracks occurs at too low crack propagation speeds and at the wrong angle to be explained this way.

Instability is the name of the game, and in this paper Ashenbach develops a necessary condition for branching on the basis of a balance of the powers involved. That required a detailed consideration of the elasto-dynamic fields near the tips of the expected branches. Let us hope that this explanation will prove out with time—or could it be that the stability of the stability is involved? The mathematically inclined had a good time arguing over the order of taking limits (both the length of an infinitesimal extension of the crack tip and the radius of the crack tip go to zero). One brave soul had the courage to inquire about the possibility of triple branching.

Several papers calculated the effects of dynamic considerations on the critical stress intensity for crack arrest. For instance, C. T. Sun of Purdue used a finite element method much like the method mentioned earlier, in which he inserted a special triangular element with a singularity to describe a crack tip. He calculated an example for which the dynamic critical stress intensity for crack arrest exceeded the static critical stress intensity by a factor of two. T. Kanazawa of the University of Tokyo pointed out that the phenomenon of crack arrest of long cracks is usually not consistent with the results of linear analysis. The question is "Is the critical stress intensity for crack arrest a material property?" Using finite element calculations to put in dynamic effects, he compared the results to experimental work on PMMA. A big dynamic effect was noted and the answer to the question was "yes." Data from Battelle Columbus on structural steel was then discussed in these terms.

A somewhat different dynamic calculation was done by George Herrmann of Stanford. He looked at a notched beam in the bending mode as a one-dimensional problem, representing the crack as a discontinuity in beam stiffness. Standard beam equations with inertia terms were used and the stress intensity factor criterion for crack propagation was taken from a standard elastic problem.

A complete history of the bending moment was calculated. PMMA in four point loading was used in experiments for comparison. Results were good up to the last 5 or 10% of beam thickness when a sort of "tail" developed on the crack as it deviated in direction. Herrmann thinks this tail results from the failure of the "infinite beam" approximation, that is, reflected waves from the ends are complicating the picture.

There were a representative number of papers on plastics, fiber glass or composites. B. W. Cherry of Monash University, Australia, discussed fatiguing of unidirectionally fiber-reinforced composites and concluded that it is Mode II crack propagation parallel to the fibers (you might call it delamination) which is principally responsible for the progressive deterioration of the physical properties. Glass fiber reinforced epoxy polyamide was used for the experimental studies in the form of a grooved cantilever test specimen. For this geometry, crack growth is stable for monotonically increasing deflection and the strain energy release rate is independent of crack length. A relationship between quasi-static crack growth rate and strain energy release rate was established and applied to the problem of fatigue crack extension rates. The observed fatigue crack extension rate was actually somewhat higher than calculated, but his could be ascribed to the temperature rise at the crack tip which was not included in the calculation. Interestingly, M. Parvin of the University of Technology, Teheran, gave a paper in another session calculating fracture toughness as a function of crack speed and ambient temperature taking into account the heating at the crack tip. Comparison with some experimental data on polycarbonate was quite impressive although the final test, measurement of the temperature in the plastic zone has not yet been done.

S. Amijima and T. Fujii of Doshisha University, Kyoto, looked at impact loading of glass fiber reinforced plastic rods using a split Hopkinson Pressure Bar method. Their point was that Izod and Charpy tests do not reveal the true impact behavior of these materials. They measured dynamic moduli 30% to 40% higher than the static values and energy-to-break considerably higher. A high speed camera was used to observe the impact fracture, and the shear-mode failure in compression was clearly visible. Y. W. Mai of the University of Sydney looked at brittle fracture of polypropylene and nylon, particularly the temperature dependence. By splitting the fracture toughness into a temperature sensitive plane-strain fracture toughness plus a temperature insensitive plane-stress fracture toughness he was able to associate the results with loss tangent peaks and β and γ relaxation processes so dear to the polymer physicists.

There were, of course, several talks viewing fracture phenomena from the point of view of the morphology of the materials in an approach which grows naturally out of classical metallurgy. This slant is not really "my bag" and I attended only a couple of such talks. Nevertheless, the paper of D.M.R. Taplin of the University of Waterloo impressed me in spite of my ignorance. It was based on data on a range of high conductivity coppers at high temperatures. Pictures were shown of the growth of voids or cavities on the grain boundaries and the details of the nucleation process for these voids were shown to affect the creep properties and fatigue life of the copper. Deformation and fracture maps were shown in which the areas of brittle fracture, high creep rate, etc., were delineated on a grid of strain range versus temperature. Such maps were recommended as aids to the practical design engineer.

B. Vodar of the Centre Universitaire du Paris Nord presented an unusual and fascinating talk on the problems of equipment for very high pressure research (ranging up to 190 Kb and, for lower pressures, temperatures up to 2000°C). He began by making the apparent but significant point that an isotropic pressure acting on a polycrystalline material does not produce a locally isotropic stress. The resulting shear may lead to initiation of small cracks. Pressure cycling can have a most dramatic effect. Fracture generally occurs in the regions where highly inhomogeneous stress occurs. For liquids under high pressures, a different set of problems occurs, chief among them corrosion cracking. Vodar cited certain solutions which in the proper circumstances induce cracking at only 40% of the elastic limit. On the other hand, high pressure oxygen will actually burn steel and is thus exceedingly dangerous. A picture of a battered steel safety screen after the failure of a high pressure apparatus made the point quite graphically. Sapphire is commonly used as a window on high pressure apparatus for gases

and liquids. Vodar described a technique used at his laboratory to relate the measured width of a spectral line to the gradient of stress in the sapphire. Another phenomenon was the breaking of a sleeve of steel from an artificial-diamond forming device of the General Electric type. This fracture occurred on the shelf, after use! The cure lay in proper prestressing during manufacture.

The program was well seeded with papers on direct applications. N. Taniguchi of Nippon Steel Corp., for instance, gave an account of some work on replacing the Charpy test for the dynamic transition behavior of structural steels with a dynamic tear test developed at the Naval Research Laboratory. The transition from ductile to brittle fracture is, of course, of great importance in designing with structural steels. Taniguchi proposed that a transition temperature for crystallinity or fracture appearance be used (rather than an energy criterion) for the dynamic tear test and noted that this transition temperature correlated well with brittle fracture arrest characteristics rather than with fracture initiation. T. Yokobori of Tohoku University gave a paper on the results of tests on vascular substitutes for medical implants. A mechanical system of plumbing and pumps was used to simulate the human circulatory system. The various mechanical parameters of an arterial system were modelled: cardiac frequency and output, peripheral resistance and arterial compliance, etc. Two kinds of artificial aortas were tested and the strength and leakage characteristics were measured. In another paper with very immediate practical applications, B.G.W. Yee of General Dynamics/Fort Worth described a search for a nondestructive evaluation (NDE) method useful for rivet holes and screw holes. The useful life of some airframe members are limited by fatigue crack initiation and growth starting at fastener holes. Yee worked with a concept of an "equivalent initial flaw size" defined by extrapolation from fractographic data generated in the course of fatiguing tests. For the NDE measurements a signature was used from a magnetic probe lowered into the hole (200 k Hz. continuous wave). The probe was of only 2 mills in diameter. The RMS surface roughness measured correlated to some degree with the mechanical tests. Fluting marks left by boring tools often were the sources of crack initiation, but some apparently smooth holes also produced cracks. The study is still in progress.

Nondestructive evaluation methods was a well covered topic at the conference. Y. Yoshioka of Musashi Institute of Technology, Tokyo, presented an X-ray method of detecting decarbonized layers on steel. It is apparently already known that X-ray line-broadening correlates with the hardness in many metals and this has been used to substitute for indentation tests for complex shapes or to avoid marring a surface. Yoshioka's laboratory also correlated this line-broadening with decarbonization of several commercial steels. Tensile residual stress was observed in the decarbonized layers as opposed to compressive residual stresses in nondecarbonized layers. The method could be used to measure the thickness of decarbonization and tended to indicate a somewhat thicker layer than did standard hardness tests. G. Caglioti of the Centro Studi Nucleari Enrico Fermi gave a talk on the acoustic emission of fracture in steel. By calculating the elastic energy converted into sound be concluded that it was of the same order as the energy of deformation at rupture. P. D. Mangalgiri of the Indian Institute of Technology, Bangalore, described some work on the acoustic emissions of plywood. By Fourier analysis of the signatures he found that there was a predominant frequency for each specimen which was independent of load. To some extent, this frequency correlated with the load at failure—but the real moral of this story was that frequency analysis can be used to gather information from the whole range of AE signatures.

S. Redner of Photoelastic Incorporated gave a survey talk on the use of photoelasticity to determine stress fields. The talk was didactic and five different methods were discussed for calculating stress intensity factors from measured fringe patterns. In a simple case, it was shown that no matter which method of calculation was used, all methods gave values within 15% of each other. Comments were also given on the problems and methods of molding suitable models. To a remark from the floor that the development of finite element methods of calculating elastic problems made digital computer solutions "better" than photoelastic "analogue" solutions, Redner replied that for reasons of price, time and delivery, his business has doubled since the advent of finite element methods. The experimenters seemed to enjoy that. To another question on the possibility of using photoelasticity to measure stress in a frightening set of extreme circumstances and in the interior of a hard body, Redner came up with an off-the-cuff but plausible suggestion of looking into the possibilities of aluminum oxide or other glasses as photoelastic elements. It was a useful talk and great entertainment too.

An earlier talk by C. W. Smith of Virginia Polytechnic Institute had illustrated these photoelastic methods to a particularly large audience. In this talk, the results of a continuing long term program were presented. The

subject was a distinctly three-dimensional situation, a nozzle in the wall of a pressurized reaction vessel. I noted that Smith considered the method as a check on finite element calculations (rather than the other way around).

The range of materials discussed at this meeting included metals, plastics, rubbers, soil, rocks and biological tissues. What is remarkable to me is the similarities of the materials rather than their differences. To be sure, the magnitudes and time scales may be of different orders, but the phenomena are qualitatively much alike. Jeffrey Fong from the National Bureau of Standards, a colleague, presented a paper on multiaxial fatigue and mathematical modelling in which he postulated a sort of correspondence principle between a class of metals at elevated temperature and a class of polymeric materials at room temperature. To justify this, he showed a plot of isochronous curves of modulus versus strain for commercial aluminum, 304 stainless at 593°C, polyethylene and PMMA. The similarities were apparent. Now, of course, there is always some phenomenon which is peculiar to each class of materials, so that the idea of material similarity must be used carefully and with insight. I do not know of a metallic equivalent to crazing for instance in polymers (though I would not be surprised to find that there is one), and in crack propagation across plates of plastic a phenomenon known as "tunnelling" occurs which is much more unusual in metal plates. But, consider the advantages of experimenting on polymers at room temperatures compared to steel at high temperature. A high proportion of the papers at this conference on fracture mechanics problems, purportedly of metals, ultimately appealed to data on polymeric materials: photoelasticity, dynamic crack propagation, wave phenomena. M. Shmuely of the Technion gave a typical paper. His finite difference calculations of fracture mechanics examined the detailed effects of the shape of crack tips on crack propagation velocity, the effects of Poisson ratio, overshoot in stress intensity and the relationship between pulse duration and critical crack length. For experimental comparisons he used data on steel and on epoxy.

By the exercise of considerable restraint I have managed to conclude this article without one of the tiresome puns on "fatigue" or "fracture" so often encountered, not even a wisecrack.

THE POLYMER RESEARCH PROGRAM AT THE TAKASAKI RADIATION CHEMISTRY RESEARCH ESTABLISHMENT

E. A. Kearsley

Polymerization and vulcanization, chemical processes at the heart of the commercial polymer chemistry business, are usually done by catalysis requiring difficult conditions of temperature or pressure. Irradiation offers an alternative method of achieving these processes without the awkward conditions and without the (often expensive) catalysts or vulcanizing agents. Since high intensity sources of radiation are available in this nuclear age (sometimes too readily, perhaps), it is not surprising that irradiation is playing an increasing role in polymer technology. Of four laboratories of the Japan Atomic Energy Research Institute (JAERI), the Takasaki Radiation Chemistry Research Laboratory is that one specifically charged with the task of promoting the use of radiation in commercial processing. I certainly expected to find a significant program in polymers when I recently visited, but even so, I was surprised on arrival to hear an estimate that about 70% of the research effort at the laboratory is directly related to synthetic polymers.

Commonly called Takasaki Genken, Taksaki Radiation Chemistry Research Establishment is about 90 kilometers northwest of Tokyo in Gunma-ken, slightly less than a two-hour train ride from Tokyo's Ueno Station. It has extensive grounds with eight or ten buildings, a staff of roughly 180 people and an annual operating budget of a little more than 300 million yen or something over one million dollars. (The reported operating budgets of Japanese laboratories always strike me as impossibly low, but I have yet to penetrate the mysteries of bookkeeping deeply enough to put my finger on the reason.) This establishment is built around three Cobalt-60 irradiation facilities and several electron accelerators. Activities range from research of a quite fundamental nature through developmental research and on to actual, small pilot-plant production runs. Food irradiation production runs have been demonstrated at Takasaki Genken, for instance, for the prevention of germination of potatoes and onions, for killing insect pests in stored rice and for the usual sterilization of perishable foods in sealed containers. These production runs were done at a special Food Irradiation Development Laboratory. The Pilot Scale Research Station does radiation induced polymerization in the gaseous and liquid state and polymerization at low temperatures, radiation cross-linking and radiation grafting of polymers. However, the Division of Research was of more interest to me, and it was there that I visited Dr. Isamu Kuriyama and his colleagues who do quite fundamental studies in polymers research related to the mission of this establishment.

Before describing the polymer research program of Kuriyama's laboratory, it is worthwhile reviewing the technological projects at Takasaki Genken, of which a number are non-polymer related. One very trendy project is the radiation treatment of exhaust gas pollutants. Irradiation has been successfully shown to remove simultaneously both SO_2 and No_x from exhaust gases. As an extra kicker, the sodium hydrogen sulfite which results is then reacted with α-olefin by electron beam irradiation to produce a soft detergent containing no aromatic rings. Two pollution birds with one stone! Engineering studies of these processes are now in progress. In a similar vein, radiation treatment of waste water beyond redemption by biological means is under consideration. Radiation-induced reactions between carbon monoxide and hydrogen are being studied with an eye to synthesis of valuable resources. Chemical reactions induced at low temperatures by fast neutrons, gamma rays and other fission fragments are being studied. Reactions in ammonia, nitrogen, carbon monoxide and hydrocarbons have been looked at so far. Another idea is to produce hydrogen by high-temperature cracking of carbon monoxide with metallic halides. The plan is to use a high temperature gas reactor in a closed cycle process. Radiation-induced chlorination, liquid phase oxidation and the cracking of ozone are also under study.

In a somewhat different vein, a mass spectrometer is being used to study the ions (positive and negative) produced by an impacting electron beam. A 600 KV pulsed electron beam generator is also used to irradiate various gases in a study of electron diffusion and the pinch effect.

The simple geometrical problem of achieving near homogeneous irradiation in a large mass of material is an important one for commercial applications. Pilot scale irradiation experiments at Takasaki Genken use a system worked out there for handling large cylindrical masses. Another system uses a moving bed reactor and γ-ray irradiation in a continuous process. The effect of the conditions of stirring of the irradiated liquids on the uniformity of the product has been clarified in the course of the development.

Polymer-related developmental work at Takasaki Genken is particularly extensive. Radiation induced polymerization is, of course, extensively studied. Pilot scale production of polyethylene by irradiation of ethylene is actively pursued. The product is a fine powder of medium density polyethylene. It has an extremely large specific area. Irradiation of solids or viscous liquids can also be used to produce solid material with very low residual stresses because the process need not significantly heat the material. Abrasion-resistant film and possibly even stable plastic lenses are seen as promising subjects for such a process.

Graft polymerization, a technique whereby two or more polymers having different desirable properties can be grafted together, can be done by ionizing radiation. This makes me think of Bernard Shaw's reply when Isadora Duncan suggested they might produce a most remarkable child, one with his mind and her body. You will recall his answer, "Yes, but what if the child inherits my body and your mind!" Presumably this problem has been solved, since at Takasaki Genken styrene is grafted onto rayon in a pilot scale plant to produce a fiber which spins better, dyes better and has better thermal setting properties than the original rayon. Graft polymerization of acrylonitrile onto polyvinyl chloride fiber is also being studied with an eye to improving the thermal properties of the PVC. Similarly the impact resistance of PVC is being improved by grafting on butadiene. High tensile strength material has been produced by irradiating a slurry of polyethylene power in various monomers. An anti-fogging coating for glass has been made by irradiation manufacture of a vinyl-silicon compound which can be used to treat lenses or glass surfaces.

For elastomeric material, radiation can be used in place of vulcanizing agents to induce cross links between polymer chains. Flame-retardant and heat-resistant electrical insulation has been produced in this way in industrial processes developed at Takasaki Genken. Extensive studies of radiation-induced crosslinking have been done and I was shown some flakes of polyethylene film which had been made transparent in this way. Samples of fluoride rubber after this treatment had improved chemical and thermal resistance.

A reverse process occurs when even heavier doses of radiation serve to break up the molecular chains of polymers rather than induce cross links or polymerization. This phenomenon may be a useful way to convert industrial wastes into valuable products. Takasaki Genken is looking at the radiation degradation of poly tetrafluoroethylene (an industrial waste) and is able to produce useful stable lubricants. They have also established that radiation degradation of atactic polypropylene results in a serviceable photo-sensitizer for polyolefins. Further studies of radiation degradation have resulted in recommendations for radiation-stable oils and radiation-resistant cable insulation for power cables to be used in a boiling water type reactor.

Radiation curing is another theme at Takasaki Genken. Current projects are a radiation-cured water-based paint, radiation-cured glass-fiber reinforced plastics, polymerization of monomer-impregnated concrete and wood-plastic composites. The polymer-impregnated concrete has high mechanical strength, is chemically resistant and impermeable. It seems a promising material to contain particularly noxious industrial wastes such as radioactive material or spent plating solutions.

Several polymeric radiation dosimeters have been developed here also, based on plaques of poly tetrafluoroethylene, cellulose triacetate and methyl methacrylate, respectively. Another type uses inorganic cobalt glass. A krypton-85 radiation source has been designed and demonstrated as useful for polymerization.

To support these technological projects, there is a substantial polymer-research program in the laboratory of Dr. Isamu Kuriyama backed up by an impressive array of modern equipment. An unusual X-ray scattering apparatus, for instance, was equipped with an ultra-sharp monochrometer. By means of a curved α quartz crystal of Johansson type, the monochrometer could transmit a copper $K_{\alpha 1}$ line as a ray 4 minutes of arc wide (between half intensity levels) and virtually eliminate the $K_{\alpha 2}$ line from the output. Scintillation counters are used as detectors and both the incident and scattered X-rays are monitored. Another more conventional apparatus for small angle scattering had a rotating anode. Other apparatus included a scanning electron microscope, a differential scanning calorimeter, differential thermal analysis equipment, a new high resolution nuclear magnetic resonance (NMR) spectrometer with a minicomputer control and data aquisition system (100 Megahertz at 22 x 10^5 gauss), an old (10 years) broad line NMR spectrometer which can operate with either of two magnets (13 Megahertz at 6 or 7 x 10^3 gauss or 16 Megahertz at 14 x 10^3 gauss). In addition there are an electron spin resonance apparatus, gel permeation chromatograph, a mechanical fatiguing apparatus capable of monitoring fatigue of a sample during irradiation and a stress relaxometer (in extension) which will handle three samples simultaneously in a thermally and chemically controlled atmosphere.

With this sort of equipment, methods of measuring crystal size distribution and other morphological data was worked out in Kuriyama's group several years ago. With the high resolution X-ray apparatus, significant differences were found between the morphology of molecularly linear polyethylene (LPE) and molecularly branched polyethylene (BPE). Now, since the early 1950's it has been known that γ-radiation will polymerize gaseous ethylene under pressure to produce a powdery polyethylene Quite naturally then, there is an extensive program in the physics of polyethylene at Takasaki Genken. Since radiation induced polymerization of ethylene can be expected to produce highly branched material rather than the LPE commonly found in catalytically polymerized material, the differences are important in estimating the commercial potential of the process. The radiation polymerized polyethylene produced at Takasaki Genken (called Takathene) has a number average molecular weight of 8.2 x 10^4, for instance, about twice that of LPE with the same relative methyl group content (based on IR measurements). Mechanical relaxation measurements and differential thermal analysis measurements of Takathene showed that molecular mobility is less than that of LPE. The material is visualized as a mixture of small imperfect crystal in an amorphous fraction. The molecules are presumably strained and immobile relative to the molecules of LPE of the same molecular weight. Through electron microscopy, differential scanning calorimetry (DSC) and gel permeation chromatography (GPC), a detailed picture emerged. The effects of the temperature at which the polymerization was carried out became apparent. It seems that the mechanism of crystallization that occurs below 55°C (lamellar crystal with irregular faces) is different from that occurring above 60°C (spherical particles), but in both cases the evidence is that folded chain crystals rather than extended chain crystals are formed. It was found that the polyethylene powder formed by radiation polymerization could easily be molded into an almost transparent film by compacting, and with pressures as low as 20 kg/cm^2 at room temperature. These transparent films too were examined by various techniques and shown to be composed of stacked small irregular lamellar crystals. Polyethylene can be produced also by irradiating various hydrocarbon solvents and alcohols rather than gaseous hydrocarbons. A thorough study of such polyethylenes has also been done.

The effects of irradiation of LPE powder have also been studied at Takasaki Genken, especially by Kuriyama and Hayakawa. Although the resulting material is not very soluble, they note that when exposed to a suitable solvent it does form a swollen gel. This gel can be studied with high-resolution NMR. With the NMR, they are in a position to monitor at a molecular level the effects of irradiation. Combining this with a classical study of the mechanical properties versus temperature, they are able to associate peaks and valleys of the resulting curves with the slipping, twisting or kinking of molecular chains or other submicroscopic components — a business dear to the hearts of most polymer physicists. For those not hep to this tune, a less occult matter is the method of using NMR for the determination of molecular weight. It was observed that polyethylene irradiated in air registered a tiny but well resolved side peak in its NMR trace at the base of the usual CH^2 peak ordinarily seen. Presumably this was due to COOH groups formed on the ends of chains during scission. In principle then, the ratio of the heights of the peaks should give a measure of the number of end groups relative to the number of groups in the chain and hence a measure of the length of the chain or the molecular weight. GPC is a standard method of measuring molecular weight, melting point (determined by DSC) is another way and small angle X-ray scattering is a third. Kuriyama's group found that all four methods agreed to within 10%, a very pleasant and impressive tally. But the oxidation of chain ends occurs only for material irradiated in air rather than

in vacuum and vacuum irradiated material produced a very different NMR trace with a smooth broad based peak. Presumably, cross links are important in this material (as opposed to scission and oxydation in air irradiated material). These studies revealed other mechanical properties and morphological differences associated with the conditions of irradiation.

Transparent sheets of considerable commercial importance are made by hot-rolling high density polyethylene. The textural changes in the polyethylene induced by this deformation are not well understood and are a subject of wide interest and study. Dr. Osamu Yoda is a member of a group which works on this problem. The high resolution X-ray scattering apparatus mentioned earlier is the group's principal tool. Using a method they had worked out earlier of extracting data on crystallite size and orientation and lattice deformation from the Fourier analysis of X-ray diffraction lines, they infer changes in morphology induced by hot-rolling. The virgin unrolled polyethylene is composed of lamellar microcrystals formed of folded chains, usually in spherulitic structures interspersed with amorphous material. This group's work shows that for roll ratios less than four (roll ratio is the ratio of the thickness of the plastic sheet before and after rolling) deformation occurs principally by a slipping between lamellae accompanied by a breaking up of the crystallites, but without a change in the amount of crystalline material. For more heavily rolled material (roll ratio greater than six) the crystallites do not break up further but some sort of chain unfolding or recrystallization may occur. These important studies are an outgrowth of earlier studies on the uniaxial drawing process.

Dr. Naoyuki Tamura is associated with some work related to the grafting of materials onto polyethylene. Methyl methacrylate and butadiene are the principal materials grafted. In this work, the electron spin resonance apparatus is the principal tool. The chemistry of the grafting process involves radicals produced by irradiation, and the kinetics of their production and consumption is the key to controlling the process. It is a complex process occurring on a microscopic level. Apparently, alkyl radicals formed by irradiation of the polyethylene migrate freely through the crystallites. On the other hand, the monomers to be grafted can diffuse through the amorphous polyethylene but not through the crystallite. Hence, it is at the surface of the crystallites that grafting is initiated and it then proceeds into the amorphous regions. On the other hand, some alkyl radicals convert into allyl radicals (the difference is that the former are saturated while the latter are not) and are trapped near or on the crystallite surface. When polyethylene has a high content of monomer to be grafted, it is the alkyl radicals which control the grafting, but when the monomer content is low it is the allyl radicals. A detailed picture of this intricate process has been worked out by Tamura and his colleagues by using DSC and ESR to study crystallinity and radical kinetics. More recently, they have been interested in trapped radical pairs. To generate good ESR traces, they have gone to single crystal mats of polyethylene or even single crystals of n-eicosane and work with these samples at liquid nitrogen temperature. For crystallites in polyethylene they have so far observed only intra-chain radical pairs but they infer that inter-chain pairs are also there. In the single crystals with relatively rigid and exact lattice geometry they have managed to see the inter-chain pairs.

In the last issue of the *ONR Tokyo Scientific Bulletin* I mentioned a "topo-chemical" reaction being studied at the Institute of Polymers and Textiles by H. Nakanishi and M. Hasegawa. In that case, light incident on a crystal of DSP induced polymerization. A "topo-chemical" reaction is also being studied at Takasaki Genken. In this case, a crystal of tetraoxane (a cyclic tetramer of formaldehyde) is irradiated by γ-rays to induce polymerization. It is a process under study at several laboratories (including my home lab, the Polymers Division at the National Bureau of Standards). The details of what actually occurs are still not established and it is a controversial subject. Yoshiaki Nakase and others at Takasaki have looked at the problem using X-ray scattering (analysed for line broadening by the method mentioned earlier), electron microscope examination, calorimetery and DSC. They find a subcrystal oriented perpendicular to the fibrillar main crystal produced at temperatures below 90°C and a lamellar type crystal parallel to the main crystal forming above 80°C. In the interval between 80°C there are thus three types of crystals found.

A test of understanding of the crystallization processes in polymers is one's ability to predict the dependence of crystal parameters on the temperature at time of growth or annealing. Kuriyama and some colleagues at nearby Gunma University are just publishing a note on some work they have done with Nylon 66 crystals. Nylon was precipitated from solution, pressed into sheets and then annealed in hot glycerol for 24 hours. DSC thermograms of the samples showed an apparently discontinuous shift of the melting temperatures with increasing

annealing temperature. Small angle X-ray scattering also revealed a corresponding discontinuous increase in crystal spacing. The data agreed well with the equation of Hoffman and Weeks for calculating melting point from the thickness of chainfolded crystals. The data on material annealed at temperatures above 180°C were consistent with a mechanism proposed by Dreyfuss and Keller for the refolding of polymer chains in crystals.

At another laboratory of JAERI, the Tokai Research Establishment, neutron scattering is used in polymer research. With this tool, radial distribution functions are measured for polyethylene melts to give some idea of the limited order occurring in amorphous material. While I did not visit this establishment, I gather from conversations at Takasaki that the results revealed little orderin the direction of chain axes, but did show a tendency for chain segments within a range something like 30 Å to lie parallel to each other.

SOME ARTIFICIAL INTELLIGENCE RESEARCH AT THE ELECTRO-TECHNICAL LABORATORY IN TOKYO AND THE UNIVERSITY OF KYOTO

Carl Hewitt

RESEARCH AT THE ELECTRO-TECHNICAL LABORATORY

In July 1971, the Japanese Government started an eight-year research and development project on a "Pattern Information Processing System (PIPS" which will require a total investment of about 35 billion yen (roughly 100 million dollars). Pattern information processing is an amalgamation of pattern recognition and artificial intelligence. The Agency of Industrial Science and Technology (AIST), a part of the Ministry of International Trade and Industry (MITI) began the PIPS Project under the auspices of the national Research and Development Programs (NRDP). The NRDP are directed toward promoting research and development of large scale technologies which are urgently needed for the development of Japan's economy and for the improvement of the nation's welfare. The programs are fully sponsored by the Japanese Government with close cooperation from both industrial and academic circles.

In fiscal 1973, the research on semiconductor large-scale integrated circuits (LSI) was amended in the area of materials and devices to meet the needs of information systems. The reason for this was that PIPS intended to develop high-performance one-chip micro-processors as described below and to realize pattern information systems as a computer complex by combining such processors. The outline of goals for the LSI project is as follows:

(1) Logic circuit
  (i) Complexity
    More than 5,000 gates/chip
  (ii) Delay time between chips
    Less than 2ns/gate
  (iii) Delay time between chips
    Less than 10 ns
  (iv) Power consumption
    Less than 0.2mW/gate

(2) Memory circuit
  (2.1) High-speed buffer memory circuit
    (i) Density
      More than 2Kb/chip
    (ii) Access time
      Less than 50ns
  (2.2) Main memory circuit
    (i) Density
      More than 16Kb/chip
    (ii) Access time

SCHEDULE AND BUDGET

The schedule of the eight-year program is made up of three over-lapping phases. The first phase includes most of the basic and internal research. The second phase includes the development of pilot models for pattern recognition subsystems and other information processing subsystems on the basis of the progress in research. The final phase includes design, fabrication, and evaluation of the overall prototype system. The figure below shows the schedule and the annual budget for the research themes of the project:

(Million Yen)

		1971	1972	1973	1974	1975	1976	1977	1978
1. Pattern Recognition Subsystems									
(1) Character Recognition	ETL contractors	29.5	78.3	68.8	67.1	57.9			
				62.3	118.9	193.8			
(2) Picture Recognition	ETL contractors	23.1	57.7	64.1	40.6	34.3			
				63.3	99.0	183.4			
(3) 3-D Object Recognition	ETL contractors	13.6	65.0	66.3	57.9	62.7			
				17.6	46.0	48.2			
(4) Speech Recognition	ETL contractors		51.9	64.1	62.9	84.4			
				20.0	37.0	98.7			
(5) Common Language and Natural Language Processing	ETL contractors	21.6	80.3	48.8	41.8	32.5			
2. Materials and Devices	ETL contractors		111.6	123.6	105.3	106.6			
		77.8	270.5	558.8	873.1	1,176.8			
3. Information Processing System	ETL contractors	24.6	323.2	401.1	467.9	492.1			
					91.9	536.3			
4. Planning and Consolidated System-Prototype	ETL contractors	6.0	14.7	16.7	18.1	62.1			
						200.4	Prototype System		
Total		196.2	1,053.2	1,575.5	2,127.5	3,370.2			

VISION RESEARCH

Masaki Oshima and Yoshiaki Shirai are working on the representation of curved objects using three-dimensional information. One of the central problems in the field of three-dimensional useful representation of polyhedra, for example, is a set of planes or edges. A good representation of general curved objects has not yet been developed. There have been some studies to represent curved objects based on light intensity information. Horn at M.I.T. has dealt with smooth objects, on the assumption that the position of the light-source and the surface photometry were known, and computed the geometry of the surface. Barrow and Popplestone at Edinburgh partitioned an image into connected regions, and gave properties of regions and their relations. There are some problems in these studies based on light intensity information. Without assumptions on illumination and optical

characteristics of the surfaces, one cannot relate geometry with image. No one can guarantee that brightness always changes at an edge. Furthermore, it is difficult to separate occluded objects.

There have been some studies on the recognition of objects based on range or three-dimensional information. Using range information this program can directly treat geometrical characteristics, and easily interpret scenes with occlusion. Shirai developed a range finder employing a vertical split projector and a TV camera, and recognized polyhedra. In finding planes, his program did not use range information explicitly. Complex objects were represented as structures of joining parts called generalized cylinders. Although the method is advantageous to representing bodies which consist of cylinder like parts, there may arise some difficulties for other kind of objects. Kyura and Shirai represent scenes by plane surfaces (three-dimensional regions), using the range finder. Their program uses grouped three-dimensional points (called surface elements), which represent local feature of objects' surface.

SPEECH UNDERSTANDING RESEARCH

Toshiyuki Sakai and Seiichi Nakagawa are working on a continuous speech understanding system LITHAN (LIsten-THink-ANswer) speech understanding system which automatically recognizes continuously uttered speech utilizing higher linguistic information such as syntactic, semantic, pragmatic information.

This system predicts possible words utilizing linguistic information at the unrecognized portion of the input utterances, and identifies the predicted word by using the optimum matching algorithm between a recognized phoneme string and the phoneme string of the word dictionary.

The system could parse sentences by tree searching, but the results of phoneme recognition and word identification are not always correct, therefore, the researchers at PIP have proposed a new tree search method.

LITHAN uses many types of a priori information; the statistics of each phoneme; the similarity matrix between phonemes; the word dictionary; the spoken grammar with the additional information as regards the spoken grammar; the semantic and pragmatic information.

They have applied this efficient, flexible system to restricted utterances which include about 100 words used to perform operational command and query the status of a computer network. When tested on a sample of 200 sentences spoken by 10 male speakers at a normal speed, 65% of the sentences and 93% of the output words were recognized correctly.

RESEARCH AT THE UNIVERSITY OF KYOTO

VISION RESEARCH

Takeo Kanade of the Department of Information Science at Kyoto University is working on a picture processing system for recognition of human faces. The system consists of several pictorial-data input/output devices under control of a high-speed minicomputer which is connected to a medium-sized host computer. It has been designed to be as flexible as possible so that it can facilitate the solution of several classes of problems in picture processing. Many examples of usage of the facilities demonstrate a wide and potential applicability of the system. Pictures of human faces have been successfully analyzed by a computer program which extracts face-feature points, such as nose, mouth, eyes and so on. The program was tested with more than 800 photographs. Emphasis is put on the flexible picture analysis scheme with feedback which was first employed in the picture analysis program with remarkable success. The program consists of a collection of subroutines, each of which works on the specific part of the picture, and elaborate combination of them with backup procedures makes the whole process flexible and adaptive. An experiment on face identification of 20 people was also conducted.

Toshiyuki Sakai, Takeo Kanade, and Yuichi Ohta of the Department of Information Science at Kyoto University are working on model-based interpretation of outdoor scenes. Outdoor scenes including sky, tree, building, car and road are complex world for computer vision. It seems difficult to realize such relatively complex

vision system without achieving the clear-cut structure of the model and the control scheme. The modelling, how to represent the knowledge, and the control structure, how to use the knowledge, are the most important and difficult problem in computer vision. They have implemented a system which obtains the interpretation of real outdoor scene using the model. First the scene is segmented into regions only based on intensity data. Then under a flexible control structure, the interpretations are assigned to the regions referring to the model which is represented by a collection of knowledge blocks. The knowledge block is the atomic element of this model and holds knowledge about a matter in the world; object "sky," material "leaves," property "blue," etc.

NETWORKS

T. Sakai, T. Hayashi, S. Kitazawa, K. Tabata, T. Kanade of the Department of Information Science at Kyoto University are working on inhouse computer network which consists of several stand alone computer systems (hosts) combined on an equal footing with each other through a high-speed communication network.

The KUIPNET (Kyoto University Information Processing Network) has been developed in accordance with the above philosophy and it is intended to supply augmented facilities for the information science research. In the subset, the IMP has the capability to transmit the data at more than 200 kbps (effective continuous transfer rate) between two processes in different host, which allows hosts to share the resources on intelligent terminals in real-time. The real-time data transfer is needed for the process cooperation related to speech or pictorial data processing.

Some applications have been greatly enhanced by the processing performance of minicomputer hosts through the sharing of resources (files, peripherals). They are now investigating the traffic characteristics of this network for performance improvement.

NATURAL LANGUAGE RESEARCH

Makoto Nagao and Jun-Ichi Tsujii of the Department of Electrical Engineering at Kyoto University are working on the analysis of Japanese sentences by using semantic and contextual information. Their parser can transform fairly complete sentences into abstract structures marked for case. A variation on the system developed by Woods called an "Augmented Transition Network" is used as the basis of their program. The parser utilizes a detailed semantic dictionary of descriptions and contextual information abstracted from sentences. It is claimed that intuitive reasoning, which is not easily formalized by rigid logical operations, plays an important role in language understanding. Some intuitively appealing schemas of representation for both the semantic descriptions of words and context are discussed. Meanings of verbs are described by using a "case" concept. Additional information is attached to case frames of each verb to indicate what changes the case elements in the frame may undergo and what events may occur in succession. Meanings of nouns are also expressed in case-frame-like descriptions. Nouns also have relational slots which must be filled in by other words of phrases. The context is represented in a form similar to that of the semantic network of Simmons or the nodespace of Norman along with some added special lists (NL–Noun List, HNL–Hypothetical Noun Lists, TL–Trapping List). These lists contain objects mentioned in previous sentences or pending problems which may be resolved by succeeding sentences. The objects in NL are ordered according to their degree of importance in the context. Several new techniques based on heuristically admissible operations are presented to analyze: 1. complex and long noun phrases, 2. conjunctive phrases, 3. anaphoric expressions and 4. omitted words in phrases or sentences. Nagao and Tsujii are applying the parsing program to the sentences in a textbook of elementary chemistry.

JAPANESE GOVERNMENT STATISTICAL ACTIVITIES

K. O. Bowman

During my visit to Mr. Hiroshi Mizuno of the Bureau of Statistics, Office of the Prime Minister, I learned that the Bureau has a history of over 100 years going back to 1871, when it was established within the main office of the preconstitutional Meiji Government. While most of the Central Government Ministries have statistical personnel as do many other national and local government offices, the Bureau has the most personnel involved with the gathering and anslysis of statistical data. Mr. Mizuno is one of two advisors within the Bureau whose responsibility is to coordinate the work. He is also a noted scholar in the area of survey methods and has had numerous articles published in the Research Memoir of the Bureau of Statistics. He is presently serving for two years as a member of the Advisory Committee of the Asian Statistical Institute in Tokyo.

The second statistical advisor, Mr. Morioka, is engaged in recording the history of the activities of the Bureau in a series of volumes. I saw two volumes in Mr. Mizuno's office and I understand there are more to come. The advisors are encouraged to conduct research on subjects necessary to carry out the Bureau's work, such as research in statistical theories, survey methods of data processing and evaluation of the survey results as well as compilation of indexes and estimates. The main activity of the Bureau is to conduct a population census every five years. In addition to this they collect other statistics of importance. The total history of census in Japan dates even further back than the history of the Bureau. In 1721, the Tokugawa Shogunate initiated a population census to be taken every six years. While they may have used crude methods by comparison to today, they nevertheless accumulated data which showed a population of approximately 30 million throughout the Tokugawa period. Census taking continued through the Meiji period and records indicate a steady population increase.

While the Bureau was initiated in 1871, the first modern population census was not scheduled to take place until 1905. The war between Japan and Russia interfered and it was actually taken as of October 1, 1920. Enacted in 1947, the "Statistics Law" is the fundamental law for the statistical activities of the Bureau. Article 8 of this law governs the activities of the Bureau as follows:

"1. Planning execution and tabulation of the population Census and other basic statistical censuses and surveys.
2. Execution and/or tabulation of statistical censuses and surveys entrusted by central and local governments.
3. Statistical training.
4. Researches in statistical techniques and methods.
5. Collection, compilation and publication of statistical publications and materials."

The organizational chart of the Bureau shows basically two distinct departments, one for survey and analysis and the other for tabulation. The survey and analysis groups, of which there are four, do some research which is project oriented rather than basic research. The tabulation groups are not involved with any research activities.

Eighty percent of the Bureau's employees are female but I observed that these are all lower ladder employees. I did not find even one woman in a managerial position. To become an employee of the Bureau a person must pass the civil examination given by the government and they compete in a ratio of one to 20 or more.

Use of machinery made in Japan is encouraged by the national government (almost all the National Universities are using native-made computing machinery). The Bureau, an exception, imported from the U.S.A. a punch card machine used in the tabulation of the 1920 Population Census; however they do display a 70 year old punched card counting and sorting machine which was made in Japan. With this long history of using non-manual devices, the IBM electronic data processing system was set up in 1961 and since then the Bureau has utilized IBM computers, including their optical reading devices. At present they have an IBM 370 Model 158 system; JEM 4400 system; NEAC 2200, model 575 system and model 200 system to carry out their computing tasks.

Since 1921 the Bureau of Statistics has also taken the responsibility for the training of statistical personnel in central and local governments. At present they provide a regular course of six months' duration twice a year with about 70 participants in each class. The curriculum of the regular course is: compulsory statistical concepts, sampling theories and techniques, data processing methods, operations research, population statistics, national income statistics, and designing of statistical surveys. Optional courses are statistical administration, mathematical statistics, regional income statistics, statistical charts, economic statistics, and statistical classification. Since 1973, the Bureau expanded its training program and gives a short course of five-weeks' duration twice a year with about 30 participants each session. This course is designed mainly for municipal officers who cannot attend a longer course. In 1973 another short course was initiated for unit chiefs in charge of statistics of central and local government organizations; it lasts five-weeks and is given once a year.

Principal publications regularly produced by the Bureau are the following:

1. Japan Statistical Handbook,
2. Monthly Statistics of Japan,
3. Statistical Handbook of Japan (annually),
4. News Bulletin (quarterly),
5. Summary of International Statistics (Annual and in Japanese only),
6. Statistics of Japan (Annual and in Japanese only).

These publications are a product of coordination of the information gathered by all the arms of the Government. Most are in Japanese and English and sales copies are purchased through the Government Publications Service Center, 1-2-1, Kasumigaseki, Chiyoda-ku, Tokyo.

Following are some interesting items about Japan compiled by Japanese Government.

1. Facts about Japan

The area of Japan is 377 km^2 with 70% of the land mountainous and 67% in forests. (The U. S. is 9363 km^2.) Japan's population stands as of the 1975 census at 111.9 million with about 45% of the population living in the three major metropolitan areas which are comprised of 9 prefectures around Tokyo, Osaka and Nagoya. According to a projection of Japan's future population made by the Ministry of Health & Welfare, the population will be 135 million in the year 2000. Currently the density is 300 persons per square kilometer, making Japan among the most densely populated nations in the world.

Educational levels are high; illiteracy is nearly non-existent. The enrollment rate for the 9 years of compulsory education for Japanese children is nearly 100% and 89% continue on to a higher education.

2. Research Activities of Science and Technology

In recent years Japan became very conscious of the problems such as the contradiction between economic growth and resource limitation and conflicts between industrialization and environmental preservation. Expenditures on research and development in science and technology (see Table I) steadily increased at an annual rate of 17%, not adjusted for inflation, during fiscal 1969-1974. If we adjust this figure by the consumer price index, increase during 1970 to 1974 is about 30%, so that the actual increase is not as large as 17% annually. In fiscal 1974, the proportions of R & D expenditure for specific purposes in the physical sector were 3.7% for nuclear

science, 2.0% for space exploration, 0.7% for oceanography, 3.8% for computer technology, and 3.9% for environmental research. A 1975 survey recorded a 51% (53% for previous year) increase over the 1974 expenditure in space development, followed by 15% in pollution measures and 13% (11% for previous year) in the development of information processing and management, 6% (15% for previous year) in energy power, and 1% decrease (35% increase in previous year) in ocean development. The ratio of R&D expenditure to the gross national product was 1.8% (2.1% to the total national income). Among the total expenditure for R&D in manufacturing industry, the electrical machinery industry occupied the highest proportion of 24%, followed by the chemical industry of 19%, the transport industry of 17%, and the non-electrical machinery of 7%.

3. Family Income and Expenditures

Table 2 shows Consumer Price Indexes for 1963-1975. During 1960 and the beginning of 1970 prices rose 3 to 7%, but in 1973, due to the oil crisis, it rose 11.7% and in 1974 it showed the greatest increase since 1949 – 24.5%. The government set a policy target of slowing down inflation to manageable rate of 15% by March 1975. 1975 showed 14.2% and in 1976 it was 8.8%, which was less than the target of 10% for that year.

Increased rates in 1975 of 13% for food, 7.3% for housing, 13.5% for fuel and light, and 6.0% for clothing were recorded. In 1976 Consumer Indexes were revised using 1975 as a base year and adjusted for index items which are necessary for accurate estimation. Compared to the consumer index the average income of workers' households has grown substantially from 9 to 25% since 1960, making the annual increase rate about 14% for the period 1970-1975. Adjusted by consumer index the real increase is about 4% annually, and the average monthly income reached 236 thousand yen (about $875) in 1975 (Table 3), and the amount of savings per household was recorded as 264,000 yen ($9778).

A 1974 National survey of family income and expenditures revealed some interesting facts; the rate of households with beds was 38.1% (29.0% in the 1969 survey), with tables and sofas for living rooms 32.9% (26.2%) and with tables and chairs for dining rooms it was 52.5% (34.2%).

The statistics were extracted from the *Statistical Handbook of Japan 1976* "News Bulletins 1976" and more details are published in the *Japan Statistical Yearbook* and the "Monthly Statistics of Japan."

Table 1

Research Activities of Science & Technology

Year	Total	Industries Research	Research Institutions	Universities & Colleges
1960	118155	42938	15808	59409
1965	194974	60982	25651	108341
1970	286439	97950	29645	158844
1975	396216	149014	39010	208192
Expenditure on R & D (in million dollars)				
1960	586	345	94	146
1965	1413	701	202	510
1970	3765	2287	462	991
1974	10059	5885 (59%)	1516 (26%)	1993 (15%)
1975	11033			

Expenditures were converted from yen to dollars.
Conversion rate (1960, 1965, 1970 – $1 = 360 yen; 1974, 1975 – $1 = 270 yen)

Table 2

Consumer Price Indexes

Year	All items	Food	Housing	Fuel & Light	Clothing	Miscellaneous
1963	69.2	'66.1	72.9	96.0	73.1	67.6
1965	76.7	74.7	79.1	96.3	78.6	75.3
1970	100.0	100.0	100.0	100.0	100.0	100.0
1971	106.1	106.1	104.8	103.7	109.0	105.9
1972	110.9	110.1	109.1	105.3	115.0	111.7
1973	123.9	124.4	120.0	111.0	139.7	120.1
1974	154.2	158.9	151.6	142.1	172.3	143.3
1975	172.4	179.5	162.7	161.3	182.7	163.1

Source: Bureau of Statistics

Table 3

Monthly Income and Expenditure of Worker's Households (in 1000 yen)

Item	1965	1970	1974	1975
Income	65.1	112.9	205.8	236.2 (875)
Expenditures	54.9	91.9	160.2	186.7 (691)
Living Expenditures	49.3	82.6	142.2	166.0 (614)
Food	17.9	26.6	43.8	49.8 (184)
Housing	4.9	9.3	15.3	16.6 (61)
Fuel & Light	2.2	3.0	5.0	6.2 (23)
Clothing	5.7	8.8	15.4	17.2 (64)
Miscellaneous	18.8	34.9	62.7	76.3 (283)
Non-living Expenditures	5.6	9.3	18.0	20.6 (76)
Income minus Expenditures	10.2	21.1	45.6	49.5 (183)

Source: Bureau of Statistics
(in parenthesis converted to dollar 1 dollar = 270 yen)

SOME QUALITY CONTROL ACTIVITY IN JAPAN

K. O. Bowman

I attended the first International Conference on Quality Control in Tokyo in 1969 and was astonished by the levels of the Japanese participants. There were present not only academicians but people from top management (including company presidents) to low management (floor foremen), all participating in the meeting. Since then, I have watched Japanese industry achieve miraculous progress in a relatively short period. We all so well remember that prewar period when Japanese goods represented a cheap price and poor quality. Today quality products such as transistor radios, TV sets, cameras, textiles, motorcycles and cars are flooding the world market.

To understand how Japanese industry accomplished such a feat, I visited Mr. Junji Nogouchi of the Union of Japanese Scientists and Engineers (JUSE) which is the moving vehicle for the activities of quality control in Japan. Mr. Noguchi is a director of JUSE which is located in Sendagaya. JUSE was established in 1946 and in 1949 it organized a quality control research group. Also in 1949 the Industrial Standardization Law concerning the application of statistical quality control was passed in Japan. In this period after World War II statistical quality control methods as well as new technology were introduced. Many foreign educators and specialists came, including Dr. W. E. Deming, who is now considered to be the father of statistical quality control in Japan.

Any company which was successful in meeting the quality requirement of the Industrial Standardization Law of 1949 was permitted to use the Japanese Industrial Standard Symbol by the authority of the Minister of International Trade and Industry, which practice continues today. Also about 1949 the Japanese Standard Organization was established and quickly passed many industrial standards using statistical quality control methods. Many prizes were instituted to be given to the companies which successfully applied statistical quality control methods. The number of industries using quality control methods rapidly increased but the procedures were still far from perfect. The reasons are well stated in "QC Circle Activities" (No. 1):

"1. Too much trend toward application of statistical methods in industry as it was carried to the extreme.

2. Standardization was promoted but with somewhat too much formality.

3. Top Management people had a sentiment which was far from being 'QC conscious,' thus resulting in no or little support and understanding by the top management."

In 1954 Dr. J. M. Juran visited Japan and introduced a new concept called Total Quality Control, meaning that quality control was an integral part of management and that everyone should participate in these activities. Total quality control activities were established in the form of training classes given at many levels from top managers to workers at the bottom level. They all participated in upgrading company products. The quality control classes were given nationwide through radio broadcasting, and November was designated as "National Quality Month." Companies subscribing to quality control methods were (and still are) encouraged to raise a "Q" flag along with the Japanese National flag atop the company building symbolizing this fact.

In 1961, an organization called "QC Circle" was born; it includes workshop level company employees and their immediate supervisors. "QC Circle" magazine reports the successful activities of this group. With this activity the actual worker on the floor is exercising a method of statistical quality control which is unique in the world and which has helped to bring about remarkable success.

Many factors were involved, one of which is the enthusiasm of the people for bettering themselves. There is practically no illiteracy in Japan as almost everyone finishes the period of compulsory education. It is customary to have on-the-job training or apprenticeships which enables the floor supervisory staff and the workers to have close relationships. The practice of auditing quality control activity by top management is being adopted by more and more companies.

A typical example was quoted ("AC Circle Activities," No. 1, 1968): In a company where there were 3,000 employees with about 200 QC Circles organized, each Circle succeeded in solving by themselves on the average of about 4 problems each year and in bringing about $20,000 in saving of operating costs annually. As of today 70,000 QC Circles are registered and their meetings held by the Headquarters (which are nationwide), regions and sections have reached as many as one every three days.

JUSE is an organization with a staff of about eighty hardworking people. In 1977, the total number of quality control courses to be given by JUSE will be about 70. These courses include some designed for top management, some for workers, 16 symposia in addition to 6 research workshops. Appendices show the contents of lecture courses.

This phenomenal success in upgrading industrial quality is only another one of the national traits that Japan has demonstrated over the years. Ever since its history has been recorded, Japan has imported skills and arts from China, Europe and the United States. There were always short periods of imitation, but in time, everything was digested, some discarded, and a new technology, method, product or art emerged as Japanese.

Appendix I

QC Executive Course

Lecture Contents

		5 days–27 hrs
1.	Management and quality control	3 hrs
2.	Quality assurance	3 hrs
3.	How to use statistical methods	3 hrs
4.	Quality control for new products development	1.5 hrs
5.	Quality control in manufacturing process	2 hrs
6.	Quality control in procurement and sales department	3 hrs
7.	Reliability and its management	3 hrs
8.	Quality control administration: organization promotion education and training	3 hrs
9.	Status and trend of quality control in Japan and in the world	2.5 hrs
10.	Initiation and promotion of quality control (case study)	1.5 hrs
11.	Group discussion and conclusion	1.5 hrs

Appendix II

QC Middle Management Course

Lecture Contents

	4 months–12 days–75 hrs
1. General consideration of quality control	6 hrs
2. Management and quality control:	6 hrs
management activities and QC organization and administration	
3. Statistical methods	6 hrs
4. Control chart methods	3 hrs
5. Quality control function in	9 hrs
production process sales process product development process	
6. Sampling inspection methods	3 hrs
7. Quality control administration:	21 hrs
initiation, promotion and education quality and reliability control vendor and vendee reactions QC and operations research practice of quality control relations between other MDT functions	
8. Special lectures:	9 hrs
quality control in clerical work status and trend of QC in Japan and in world quality assurance	
9. Group discussion	12 hrs

Appendix III

QC Basic Course

Lecture Contents

		6 months–30 days–180 hrs
1.	Introduction	3 hrs
2.	Quality control administration	3 hrs
3.	Quality–design, production and sales	15 hrs
4.	Cooperation with affiliated companies	3 hrs
5.	Human aspects of quality control	3 hrs
6.	Treatment of data	6 hrs
7.	Probability and statistics	9 hrs
8.	Statistical test and estimation	
9.	Stat. test and estimation for variables	9 hrs
10.	Stat. test and estimation for attributes	3 hrs
11.	Control charts	9 hrs
12.	Sampling inspection	15 hrs
13.	Analysis of variance	6 hrs
14.	Correlation analysis	1.5 hrs
15.	Simplified methods	2 hrs
16.	Binomial probability paper	2.5 hrs
17.	Linear algebra	6 hrs
18.	Regression analysis	9 hrs
19.	Orthogonal multinomial equation	3 hrs
20.	Analysis of variance and design of experiment	12 hrs
21.	Sampling methods	7.5 hrs
22.	Work sampling	1.5 hrs
23.	Reliability engineering	6 hrs
24.	Methods of optimization	3 hrs
25.	Sensory test	3 hrs
26.	Circumstances of QC	3 hrs
27.	Computer	3 hrs
28.	Case study	3 hrs
29.	Special lecture	6 hrs
30.	Exercise	15 hrs
31.	Free discussion	3 hrs
32.	Meeting for presenting on subjects studies	6 hrs

Appendix IV

QC Elementary Course

Lecture Contents

8 days–54 hrs

1. Quality control administration: 12 hrs

   What is QC?
   improvement of production process
   control of production process
   how to promote QC

2. Statistical methods: 27 hrs

   treatment of data
   variation of data
   stat. test and estimation
   analysis of variance
   correlation analysis
   simplified methods

3. Control charts methods 6 hrs

4. Inspection 3 hrs

5. Exercise 5 hrs

6. Question and answer 1 hr

A LOOK AT SOME ON-GOING RESEARCH AT THE METROPOLITAN INSTITUTE OF NEUROSCIENCES

Morton A. Bertin

As the name implies, the Institute is under the jurisdiction of the City of Tokyo Municipal Government. My host for this visit was Professor Eiichi Iwai, a physician who is the Director of the Division of Medical Psychology. I had the opportunity of meeting with all of the members of the professional staff and to look in on the work in process in the modern and well-equipped laboratories. The Institute was established only four years ago and is housed in a modern facility as part of a hospital complex in the outskirts of Tokyo. It might be said that they are just about gearing up for some exciting work, and it was evident that the mostly young researchers are highly motivated and very eager about what they are doing.

Professor Iwai defined their major area of interest as being neural behavior and its relationship with visual learning. There are three branches: behavioral, electrophysiological, and anatomical, but work in the behavioral areas has received most attention to date. Almost all of the work is performed with rhesus monkeys. It appears from our discussions that Imai considers that he is just beginning to scratch the surface, which is understandable in light of the short time that the group has been in existence.

In one study of visual discrimination with removal of the inferotemporal cortex (IT), Iwai and his associates explored pattern perception by IT monkeys. Subjects were an IT monkey and a normal (N) monkey who had both been trained to discriminate between white triangles and white circles on black backgrounds. The study was designed to explore whether monkeys discriminate stimuli on the basis of patterns within the stimuli, regardless of their being normal or brain damaged. After the initial training process, the triangles and backgrounds were inverted in some of the stimuli sets and the monkeys were retrained. The percent of responses correct for the trials where the patterns were inverted were significantly lower for the IT monkey than for the normal, but where the pattern was the same, the IT monkey scored very high. On the other hand, the normal monkey scored almost perfect on all trials for all sets. The experimenters conclude that the IT monkey, unlike the normal, discriminates visual stimuli using cues other than those patterns by themselves. This raises some doubt concerning the accepted concept of how an IT monkey identifies visual patterns.

In another study of visual impairment following ablation of the prestriate association cortex (Prest) in monkeys, they investigated the puzzle of why none of the animals had shown a significant impairment of visual discrimination. In the few previous studies which reported positive results, the lesions were largely in the inferotemporal area, which raises the question of whether the results were due to damage to IT rather than to Prest. Iwai discussed a hypothetical model that has been presented asserting that IT's participation in vision depends upon a linkage with the striate cortex through a relay in Prest, and he and his associates undertook to investigate whether complete ablation of the foveally representative area of Prest (For-Prest) could produce some impairment of visual discrimination.

The subjects were six monkeys, with three each in the experimental and control groups. Type and extent of lesions are shown in Figure 1. Following some initial exposure, the animals were trained to discriminate between white patterns on black backgrounds. After the surgery, the experimental animals rested a few weeks before being retrained to the same criterion as before. All of the experimental monkeys showed a significant deficiency in visual discrimination, which the researchers assert indicates that for the first time bilaterally symmetrical lesions of Fov-Prest resulted in marked impairment of visual discrimination. Controls with various

cortical lesions did agree with previous studies. It appears from the histological examination and other factors discussed that the conclusions are warrantable and that the study does indeed throw new light upon longstanding questions concerning Prest functions.

A final round table discussion with all of the members of the staff was particularly rewarding, especially, as stated at the outset, witnessing the enthusiasm of the young and talented researchers.

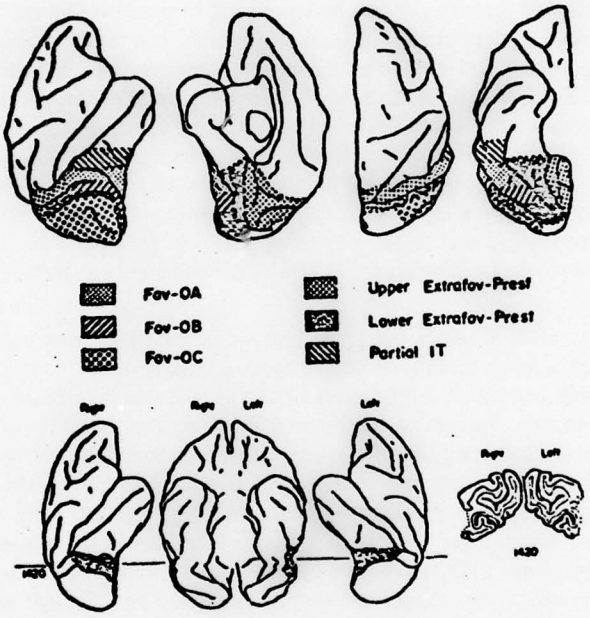

Fig. 1. Upper: Diagrammatical representations of various lesions made in right hemisphere. From left to right; lateral, medical, dorsal and ventral views, respectively. Lower: Representative reconstructions and a cross section of Fov-Prest lesion (Monkey 3).

THE NATIONAL INSTITUTE OF VOCATIONAL RESEARCH REVISITED

Morton A. Bertin

A visit to the National Institute for Vocational Research (NIVR) a few years ago was limited because of time pressure, but my interest was sufficiently whetted to warrant a return. This time I met with several of the researchers and had the opportunity of reviewing many of the programs. From the germ of an idea born four years earlier, the Institute came into being in 1969 as an arm and under the support of the Japan Ministry of Labor. Its stated aim is to "contribute to the development of career guidance in educational institutions at all levels from secondary schools through colleges in Japan, and to promote the enhancement of the employment security services for workers." More broadly, its concern is with man in the world of work through research and study on vocational adjustment and vocational behavior. There are three research divisions, with considerable overlap and interaction. The first deals with the study of employment service, vocational guidance, and personnel management and is called the adjustment section. The second or aptitude division is concerned with research on development measurement, evaluation of vocational abilities, capabilities of the handicapped, and potential for employment of the elderly. The occupation division is involved in job analysis and redesign, occupational outlook, classification of occupations, and the world of work for women. The approach is interdisciplinary involving psychology, sociology, pedagogy, economics, physiology, and statistical mathematics. The Director is Hiroshi Kaneko, formerly a professor at the Institute for Research in Productivity at Waseda University.

A major series of studies is under the general rubric of career development of Japanese youth, but the reason behind the studies is much more pointed and specific to a particular threat to the world of Japanese employment. The normal expectation of the Japanese employer, and also the worker, that employment is a lifetime commitment between the two, appears to be threatened by the dissatisfaction of young workers who become disenchanted with their jobs and leave, creating a large (for Japan) employment turnover. In order to investigate the career patterns of the young, a ten year study was instituted to follow up the vocational behavior of young workers after they completed lower secondary school, studying their attitudes, viewpoints, and job-changing behavior in a longitudinal effort. Over 3500 students from 89 classes of schools selected at random from seven prefectures are the sample population. They have been followed through two channels: those who dropped out after the lower secondary school and those who continued on into and through high school. The follow-up surveys are carried out either through personal interviews or mailed-out questionnaires. All told there will be eight surveys and preliminary analysis has been completed from data of the first four. As might have been expected, intelligence is the prime factor of whether or not the students continue into high school.

In an attempt to discover satisfaction of the course followed, the students (and ex-students) were queried as to whether or not they were happy that they dropped out or went on. Of those who dropped out it was just about evenly divided on happy or unhappy. Of the unhappy group, 40% were disappointed in their jobs, 30% regretted not going on to a university, and 30% had a wide variety of dissatisfactions. The data being collected has imposed massive analysis problems, but a few things have emerged and have been presented in an interim report. The comparison made at this stage is between the lower secondary school graduates (LSSG) and the upper secondary school graduates (USSG), all about age 19. Those who graduated from secondary school had entered the labor market at that stage and similarly for the upper graduating group. The findings were that as groups there were no differences in the vocational self-images between them, though there were exceptions in individuals in both groups. These occurred mainly in the LSSG group who apprenticed to artisans or craftsmen and who exhibited a job-oriented self-image. Also, some of the upper group who worked for public services or large organizations showed through their self-image that they were company-oriented.

In another study of occupational mobility and structure, some 6000 male workers between ages 20-69 were sampled at random from various sections of Japan, using interviews. The variables analyzed were relations between age and career life style, frequency of change of employment, and the conative (or restless) nature of vocational behavior. Results of the study indicated that the average number of job changes per person over a career was 2.1, with about 22 percent staying with one job throughout. Also, although the father's occupation may exert some influence on vocational selection, the modern young job seeker is more self-assertive in this decision. Although about 62 percent of the older members of the sample received their jobs through parental or other connections, this declined for the 35 percent of those who were the younger subjects, and there were definite differences between the two age groups related to their attitudes towards their career. A similar study is presently underway with female workers.

One of the problems of providing vocational guidance to students in the Japanese school system is the lack of trained counselors available. In response to this the Institute has developed a Vocational Readiness Test for junior and senior high school students, designed to provide guidance in personal preferences. An aim is also to instill some confidence in the student in acquiring an understanding of himself. The Institute provides instructional seminars to teachers so that they become qualified to interpret the responses, though the test is largely self-explanatory. Similarly, the members of the staff of the Institute are available to provide information on the use of several instruments to the many vocational agencies under the Ministry of Labor. There is also a Readiness Test which is administered yearly to some 200,000 junior and senior high school students, primarily to those vocationally oriented, though it is also occasionally used with those who opt for a university career. It provides a relatively simple guide for self-counseling.

Specific projects on the fire for the near future are studies designed to evaluate the vocational aptitudes of the handicapped, both physically and mentally, in order to enhance their job potential; counseling for elderly workers who seek to continue being gainfully employed beyond their normal retirement age; and scrutinizing, analytically, new types of jobs that have appeared on the labor market in the last ten or so years. The purpose of this is to provide up to the minute vocational information to young job seekers on labor possibilities. The Institute produces several publications including the *NIVR Bulletin*, a semi-annual professional journal which contains papers of their research studies; *Vocational Research*, published quarterly for non-professionals, designed to provide a better understanding of the world of work, particularly in Japan; finally, the Job-Description is designed for young workers and secondary school students for use in career guidance.

PSYCHOLOGICAL RESEARCH AT TOKYO METROPOLITAN UNIVERSITY

Morton A. Bertin

Supported by and under the control of the Tokyo city government, Tokyo Metropolitan University is one of the most difficult in the city to enter. The competition is very keen and the entrance examinations extremely difficult, partially a function of the tuition factor, costs being substantially less here than in the private schools. It is a relatively small school with a student enrollment of about 2000, 300 of whom are graduate students. The faculties are humanities, law, economics, engineering, and material sciences. Under humanities there are 9 departments: psychology, philosophy, education, history, Japanese literature, English literature, French, German, and Chinese. Each has a graduate program awarding both the M.A. and the Ph.D. The staff of the psychology group consists of three professors, three associates, and five instructors. I met with several of them in round table discussions and reviewed the past and on-going research.

Taketoshi Takuma, who teaches courses in personality and intelligence, maintains a research interest in the behavior and character of twins. He has examined the influence on children of the different ways they are raised and concludes that the educational patterns, which largely depend upon cultural influences, prove to be of primary importance. He found that the traditional "special rights" of the first-born child in Confucianism also appears to hold for identical twins, with parents differentiating between the first-born and the one born immediately thereafter. Despite the proximity of births in time, identical twins demonstrate character differences which are generally attributable to elder and younger siblings. He has also used the twin study method to investigate heredity and environmental influences upon the development of intelligence. He studied groups of 12 year old monozygotic (MZ) and same-sexed dizygotic (DZ) twins and found data contradicting several former findings relative to the high level of conformity among MZ twins, differences which he attributes to environmental factors. In pairs with great intra-pair differences in weight, the heavier twin generally produced the higher intelligence score. Where there was a long intra-pair interval in birth, the first-born achieved the higher score, and where there was a wide diversity of scores there was also a substantial difference in early ability to walk and/or talk. There was a definite relationship between early physical differences and the development of intelligence.

Shojo Imai is a perceptual psychologist specializing in optical illusions. In one of his earlier studies he attempted to measure the magnitude of the visual distortions in the different kinds of illusory figures consisting of straight and curved lines. He found that the amount of illusion decreased with increase of distance between straight and curved lines and that there was an optimal curvature for the illusion. He also investigated the effects of circular arcs on visual shape distortion of a circle using psychophysical measurements. He found that the ends of a pair of circular arcs placed on a circle were seen to deviate inward or outward from the circle and that here also there was an optimum span of arc to create the illusion. Using four types of illusory figures, Imai was able to show significant correlations between magnitude of illusions and judgment time and the confidence of the judgment with the personality characteristics obtained by using the Yatabe-Guilford Personality Test.

Eitaro Masuyama teaches human engineering and mathematical psychology and is primarily interested in transfer functions. In an experiment dealing with transfer functions of operators following random wave outputs, he studied the relationship between the shape of the input spectrum and human control characteristics and the relationship between pursuit-compensatory activities and the human control characteristics. It was found that as the rate of cut-off increases and the operator changes from compensatory to pursuit tracking, his open-loop gain increases and mean square error decreases. Thus it appears that he improves tracking performance at the sacrifice of stability. In another series of experiments Masuyama and his associates use a hybrid computer to determine which conditions in an automobile driving simulator best satisfied actual driving conditions. In a

follow-on experiment it was determined that in a man-machine system, the dynamics in the case of random input signals is almost equal to that in the case of step input signals. Masuyama and I discussed the outlook for engineering psychology in the universities and it appears not to be overly bright. He attributed this to the fact that it is not well accepted by the engineers who possibly stand to gain the most from it. It appears that most advanced research is being carried out in institutes and government laboratories, where work is directed at solving highly applied problems.

Noriaki Kato has a primary interest in social perception and has used the rod frame test to investigate its basic characteristics and its relations to personality traits. The basic findings were that larger error in the test correlates highly with inferiority, subjectiveness, uncooperativeness, social introversion and social maladjustment. Also, there were sex differences in the extent of error with women showing larger errors, a fact which Kato interprets to show that they are more field dependent. Errors were gradually eliminated with practice. Individual and conditional differences in the mean errors were large, but the internal consistency was high. In another study he attempted to obtain a relationship of verbally and projectively expressed preferences of parents in kindergarten children using a projective depth perception test. In this test the drawings of preferred parents were set closer to the place the subject is shown to be standing than the less preferred parents, and this tendency increased for stronger preferences. Further, the size of the preferred parents were shown to be larger than those of the less preferred and purple color was used more for these less preferred.

Shoichi Shinohara teaches animal psychology and psycholinguistics. With others he has studied how monkeys use color and form as cues to solve problems. In one such experiment the solution of simple oddity problems was the critical task and it was found that color cue was more dominant than was form cue. Also, it was observed that there was a transfer effect from previous oddity training. In a later experiment to test the relative efficiency of color and form as cues to learn matching to sample problems, the same findings obtained, and transfer was again noted from previous training.